SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JUNE 1920.

GENERAL PHYSICS.

790. *The Universal Measuring Machine.* (Engineer, 129. pp. 472–473, May 7, 1920.)—This machine, which has been steadily improved since its invention about 20 years ago by the Société Genevoise d'Instruments physique, is not merely a comparator like several other measuring machines, but gives a direct comparison of a length of material against a length on a line standard. It deals with over-all lengths, and also with under-all lengths, such as the interior diameter of a ring; it also has special fittings for measuring the full, core, and effective diameters of a screw. In the most recent form of the machine contact is shown by the movement of a multiplied lever, such as is so much employed in minimeters. In this way it is not necessary to look through a microscope for every reading of length. P. E. S.

791. *Apparatus for Drawing Conic Curves.* **A. F. Dufton.** (Roy. Soc., Proc. 97. pp. 199–201, April 15, 1920.)—With the apparatus described in this paper, the conic is drawn as the polar reciprocal of a circle. The circle to be reciprocated, of centre O and radius ON, is enveloped by a straight line AB. The points A and B lie upon a fixed straight line at a distance ON from O, and the paper containing the circle is rotated about O. To the paper is fixed, at the centre of reciprocation, which becomes a focus of the conic, the joint S of a four-bar linkage. Two equal bars SC and SD are hinged to the middle points C and D of equal bars, ACP and BDP, hinged together at P. This linkage has the property that P is the pole of AB with respect to a circle of centre S, and radius $(SC^2-CP^2)^{\frac{1}{2}}$. For, if PK and CM be perpendicular to AB and SP respectively, $SK \,.\, SP = (SM - KM)(SM + MP) = SM^2 - MP^2 = SC^2 - CP^2$. P therefore describes upon the paper the polar reciprocal of the circle of centre O and radius ON, *i.e.*, a conic with focus S, axis SO, eccentricity OS/ON, and latus rectum $2(CP^2 - SC^2)/ON$. A photograph is given of the first rough model of the apparatus, and also a diagram of curves drawn with it. A. W.

792. *Measurement of very Short Time Intervals.* **P. E. Klopsteg.** (Phys. Rev. 15. pp. 12–23, Jan., 1920.)—*A partial deflection method.*—After briefly reviewing the usual method of determining time intervals of the order of microseconds, the author describes a method in which the p.d. of a condenser after it has been discharged for the interval of time to be measured, is accurately determined by connecting the condenser through a ballistic galvanometer to a known p.d., which is made nearly the same as that to be measured, so that the small throw observed merely measures the small correction to be applied to the known p.d. to give the unknown. A steady current through a known resistance is used as the source of known potential difference. The arrangement of circuits is described and also a gang switch which simplifies the experimental manipulation and eliminates possible error from absorbed charge in the condenser. The working equation for computing the time interval from the observations shows that the attainable accuracy depends on the accuracy of a resistance, a resistance ratio and a capacity. The method was tested with the aid of a Helmholtz pendulum and it was shown that an interval of 250 microseconds may be measured with such *accuracy* that the probable error of each observation need not exceed 0·15 %. The *precision* was such as to enable the determination of an overall temperature coefficient of the Helmholtz pendulum and accessories amounting to about 1 microsecond per degree for the interval just mentioned.

Measurement of the rate of detonation of explosives ; a source of error. —An attempt to apply the above method to measure the rate of detonation of dynamite and trinitrotoluol gave inconsistent results, probably because, on account of the intense ionisation, the condenser continued to discharge through the gas after the wire was broken. AUTHOR.

793. *Graphic Method for Plotting Reciprocals.* **F. E. Wright.** (Washington Acad. Sci., J. 10. pp. 185–188, April 4, 1920.)—Describes, with diagrams, a method for plotting reciprocals without resort to specially ruled paper. The X-scale is transferred from the X-axis to a parallel position unit (positive) distance away. A series of radiating lines is then drawn from the origin through the divisions of the X-scale, each radiating line corresponding to the X-scale division which it intercepts. Instead of plotting a given point (h, k) in the usual manner, the point lying on the line joining the origin to the h scale division and whose ordinate is k, is taken. It is easy to show that if a series of points, such as (h, k) lie on a rectangular hyperbola, then the series of corresponding points on the radiating lines will be on a straight line. A. W.

794. *Construction of Transport Vessels for Liquefied Gases.* **F. Banneitz, G. Rhein,** and **B. Kurze.** (Ann. d. Physik, 61. 2. pp. 113–144, Jan. 15, 1920.)—The general principles underlying the construction of vessels for the storage and transport of liquefied gases are discussed and the results given of tests made with various vacuum-jacketed vessels of glass, celluloid, and metal. It is found that even with iron vessels the necessary high vacuum is attainable, provided that the soldering —best with silver solder—is carried out with great care and that the vessels are subjected to prolonged exhaustion at about 300°. For small vessels the inner neck may be insulated from the outer vessel by insertion of a glass tube, made tight with the metal on both sides by means of platinum rings, whilst for larger vessels sufficiently long tubes, for instance, spirals, of badly-conducting metal may be used. The thermal conductivity of naked iron or nickel is, however, far too high, and these metals are best coated with silver ; the silvering must be effected galvanically, and not by the spraying process, since the sprayed metal adsorbs very large proportions of gases, and, further, is not sufficiently smooth. Tin-plating was not tested, tin being unobtainable in Germany. Since the metallic coating is injured by excessive heating, exhaustion must be carried out at moderate temperatures (up to about 300°). The loss owing to radiation and to conduction in the highest vacuum may be diminished by about one-half by insertion of a well-insulated partition silvered on both sides.

When the above precautions were observed, the best result obtained was given by a 2-litre silvered iron vessel, the daily loss being 0·6 kg. of liquid air. On the assumption that the loss is proportional to $v^{2/3}$, this would amount to 38 kg., or about 4 % per day for a vessel holding 1000 litres. T. H. P.

795. *Strength of Riveted Joints.* **J. Montgomerie.** (Inst. Eng. and Shipbuilders, Trans. 63. pp. 20–34, April, 1920.)—Describes experiments on the strength of riveted joints, both triple and quadruple, and using different methods of riveting, with both steel and iron rivets. The apparatus and method are fully described and illustrated in the paper. It is found that (i) the load is not evenly distributed among the rivets, and no uniform state of stress exists anywhere in the joint. (ii) For pulls up to the point at which slip takes place, the maximum stress occurs in each plate on the surface next the edge of the joint. At this point the stress is nearly double the stress in the normal plate. On the opposite surface the material is practically unstressed. (iii) Slip takes place in the joint when the pull applied, distributed over the area of the rivets, produces a stress figure of from 7·5 to 8 tons per sq. in. Up to that point the joint behaves as an elastic solid. After an interval the joint recovers its power of adhesion and gives a similar result, on retesting, to that already obtained. (iv) The pull producing slip, when referred to the sectional area of the normal plate, and to the area of the material between a line of frame rivets spaced seven diams. apart, corresponds with a mean stress of 9 and 11 tons per sq. in. respectively. (v) No appreciable distinction can be drawn in regard to the elastic qualities or ultimate strength of the joint in respect of the method of riveting employed, or the rivet material used. (vi) The average strain measured over the whole joint does not materially differ from that found in the surrounding material. (vii) In a lapped joint the rivets in the outer rows are more severely stressed than those in the inner rows.

J. W. T. W.

796. *Density of Elements at Absolute Zero.* **W. Herz.** (Zeits. Anorg. Chem. 105. pp. 171–174, April 3, 1919.)—Making use of the relations between volumes V and density d at absolute zero, boiling-point T_s, critical temperature T_k, and melting point T_e, according to R. Lorenz [see Abs. 986 (1917)]: $d_0 = 1{\cdot}41d_s = 3{\cdot}75d_k = 1{\cdot}21d_e = d(0{\cdot}77 + 0{\cdot}64T/T_s)$, the author shows that this relation holds approximately for O, H, N, Hg, Na, K, Cs, Al, the inert gases, etc. The agreement is not always good; the d_0 deduced from the various ratios varies for Hg, for instance, between 14·2 and 17·4, and while the density increases in natural groups with the atomic weight, sodium has a greater d_0 1·083 than potassium, 1·004. H. B.

797. *Structure of Crystals in Thin Laminæ. Optical Determination of Molecular Dimensions.* **R. Marcelin.** (Ann. de Physique, [ix] 10. pp. 189–194, Nov.–Dec., 1918.)—Thin laminæ of the substance of uniform interference colour are examined between crossed nicols, and the colour is compared with that of a wedge of quartz; the thickness of the lamina is calculated from the wedge thickness at the point and the refractive index. Very fine laminæ of mica are obtained, after R. W. Wood, by pressing a thin sheet of mica against fused selenium and tearing the mica off again after cooling; fine scales are left behind. Assuming the mica molecule to be spherical, its diameter would be $0 \cdot 70\ \mu\mu$; laminæ, one molecule in thickness, are observed, and thicker layers represent multiples of that dimension. In the case of *p*-toluidine the molecular diameter ranges from $0 \cdot 3$ to $0 \cdot 7\ \mu\mu$, and laminæ of two molecules, possibly only of one molecule, seem to exist. H. B.

798. *Poiseuille's Law.* **J. Schleier.** (Phys. Zeits. 21. pp. 14–15, Jan. 1, 1920.)—A system of 378 tubes was built up, so as to represent to a certain extent the blood system in vertebrate animals. Measurements of the tubes allowed the flow to be calculated from Poiseuille's law, and the calculated values in a series of concordant experiments did not differ by more that 7 % from the observed values. A difference was to be expected, since many joints were made with short lengths of rubber tube, so that the results tend to prove the validity of Poiseuille's law for a system of connected tubes. A. W.

799. *Vortex Motion.* **H. Villat.** (Comptes Rendus, 170. pp. 449–451, Feb. 23, 1920.)—The case of cyclic motion in a fluid with vortices arranged at the vertices of a regular polygon is considered. The more complex case in which they are arranged in a ring is then dealt with, and from that the cyclic movements around a regular solid immersed in a fluid are studied. W. A. R.

800. *New Method of Driving off Poisonous Gases.* **[Mrs.] H[ertha] Ayrton.** (Roy. Soc., Proc. 96. pp. 249–256, Oct., 1919.)—A description is given of the hitherto unsuspected conditions created in the air by striking a surface with a blade which accommodates itself to it, so that all the air is expelled from between them. By constructing the blade so that all the air was sent *forward*, and attaching a handle to it, a remarkably efficient hand fan was obtained, which was used at the front for getting rid of poisonous gases. Each stroke of such a fan, on a horizontal surface, say, creates a horizontal vortex, rotating so that its upper boundary moves towards the fan, while the vortex as a whole recedes from it. If the strokes are made so quickly in succession that one vortex has not come to rest before another is formed, each merges in the last as soon as their boundaries touch, and finally one great vortex is created where the energy of each arriving vortex exactly balances that lost in friction. The vortices sweep ahead of them, and upwards, all the gaseous contents of the space through which they move, and this space is very great, in all three dimensions, compared with the size of the blade that produces the vortices. With 24 taps of a blade 1½ in. square, an advancing cloud of smoke 6 ft. wide was driven back 8 ft., and up about 1½ ft. With a blade 15 in. square, smoke was driven back about 75 ft., and up over trees from 12 to 15 ft. high. Some of the laws of the air disturbance are given. AUTHOR.

801. *Viscosity of Sulphur.* **C. C. Farr** and **D. B. Macleod.** (Roy. Soc., Proc. 97. pp. 80–98, April 1, 1920.)—The viscosity of the molten sulphur was measured by the method of rotating cylinders. A glass tube containing mercury and a thermometer was suspended, either by bifilar or unifilar suspension, in another tube containing molten sulphur kept at a constant temperature by means of a regulated heating bath. The tube containing the sulphur was rotated at a definite speed, and the torsion on the mercury tube measured by a mirror and scale arrangement. The results obtained are as follows: The viscosity of purified (twice distilled, but not gas-free) sulphur is 0·1094 c.g.s. unit at 123°. It falls to a minimum of 0·0709 at 150°, and then gradually rises with increase in temperature to 159°; on further increasing the temperature the rise becomes more marked, but there is nothing in the nature of a strict transition point. Exposure to the air in a molten condition, especially below 160°, has a most marked effect on the viscosity from 160° upwards. The effect is a slow one, the viscosity, as measured at 171°, continuing to rise for as much as 48 hours on exposure for that time to the air. The maximum for purified, unexposed, gas-free sulphur is reached at about 200°, and has a value of 215 c.g.s. units; the maximum for purified, not gas-free, sulphur, but after long exposure to the air, is reached at a lower temperature, namely, about 190°, and can have a value as high as 800 c.g.s. units. Crystallisation has an apparent, it may be a secondary, effect upon the viscosity as measured at any temperature; it apparently raises the viscosity, as measured at, say, 171°, of a low-valued sample of sulphur, and lowers the viscosity of a high-valued sample. The effect of crystallisation seems to disappear when the viscosity of the sample, as measured at 171°, is about 300 c.g.s. units. Sulphuric acid, formed from exposure to the air, appears to be the chief impurity which causes the extreme variations which are to be found in the values of the viscosity of air-exposed sulphur. Dissolved gases, such as ammonia and sulphur dioxide [compare Smith, Holmes, and Hall, Abs. 1946 (1905)], also affect the viscosity, but their influence is to be further studied. It is shown that the higher the percentage of insoluble sulphur (S_μ) present (compare Smith and Holmes, *loc. cit.*), the greater is the viscosity at any particular temperature. T. S. P.

802. *Theoretical and Experimental Researches on Gravitation.* **Q. Majorana.** (Phil. Mag. 39. pp. 488–504, May, 1920.)—The question is raised in this paper as to the absorption by a dense medium of the energical flux which is supposed to proceed from all matter and cause gravitative attraction. A particle of mass *dm* would put forth a flux *kdm*. If this flux passes through distance x of a dense medium, having quenching factor H, the flux at the end would be $kdm\,.\,e^{-Hx}$. Here H is proportional to the density of the medium $= h\,.\,\partial_v$. Now, suppose the particle of mass *dm* to be a particle inside a sphere, the author finds that the total flux emerging from all points in the sphere is

$$F = k\pi\partial_v R^3[1/p - 1/2p^3 + e^{-2p}(1/p^2 + 1/2p^3)],$$

where ∂_v = density of the sphere, R = radius of the sphere, and $p = RH$. Let M_a = the apparent mass of the sphere. This is less than the true mass M_v on account of this absorption effect. Let $M_a = M_v\psi = \frac{4}{3}\pi\partial_v R^3\psi$, where $\psi = \frac{3}{4}[1/p - 1/2p^3 + e^{-2p}(1/p^2 + 1/2p^3)]$. The relation of p to ψ is shown graphically. The case of the sun is specially considered. The astronomical density of the sun is 1·41. This is the apparent density. On certain hypotheses we can arrive at a value for the true density, and from this deduce the values of ψ, p, and H successively. The values of ψ, p, and H the authors draw up in a table, giving a range of hypothetical density from 1·41 to 20·0. For a material of density 1·0 the value of H is h. This factor h is supposed to be a universal constant of value between 10^{-12} and 10^{-11}.

In order to find the value of h, the author has performed the following experiment. From a delicate balance *in vacuo* hangs a lead sphere, counterpoised by a similar sphere. One lead sphere is hung in a chamber surrounded by one which can be used empty or filled with mercury, so as to surround the lead symmetrically. The lead has mass 1274 gm., the mercury has mass 104 kg. By means of a mirror, the balance, and a distant scale it is possible to estimate the mass to 1/1700 mgm. on each reading. On trying the experiment, the author finds that in all cases the weight of the lead is reduced when it is surrounded by mercury. This indicates an absorption effect by the mercury. The observed decrease in weight is (0·00209 ± 0·00007) mgm. But various corrections must be applied. These include the attraction of the mercury on the counterpoise, and on the beam, and on other parts used. The greatest admissible error for asymmetry of the mercury is ± 0·00009 mgm. The net effect after the application of these corrections is (0·00098 ± 0·00016) mgm. The author next considers other possible causes of error, such as electrostatic or magnetic action, radiometric or electromagnetic action, heat effects, and mechanical perturbation. He considers these effects negligible.

The value found for h is $6{\cdot}73 \times 10^{-12}$. On applying these results to the sun, the author considers the sun's true density to be 4·27, which is *three times* as great as that believed in by astronomers. P. E. S.

803. *Thickness of the Capillary Layer between the Homogeneous Liquid and Vapour Phases.* **G. Bakker.** (Ann. d. Physik, 61. 3. pp. 273–302, Feb. 3, 1920.)—Basing the theory of the capillary layer upon the J. Thomson-van der Waals isothermal, the author had shown [Abs. 1888 (1906) and 613 (1918)] that there are, on this isothermal, three points for which the thermodynamical potential has the same value; two of these points are given by the intersections between the physical and theoretical isothermals, the third is his point F. The general equation is $T^2 d\left\{H/\zeta T\right\}/dt = \frac{1}{2}(E_1 - E_2) - E_3$, where T is the absolute temperature, ζ the thickness of the capillary layer of surface tension H (numerically equal to the capillary energy), and the E are the energy-densities of the liquid and vapour phases and of the phase F respectively. When this equation is integrated, $d\zeta/dt$ has to be neglected for simplification; the ζ values then obtained are of the correct order, though a little too small. In the author's previous calculations of ζ for CO_2, the energy formulæ of Gauss, van der Waals, and of Mills had been applied; the new calculations made after Clausius-Sarrau are found to agree with the previous values. In the second part of the paper another approximate method is used. When pressure = kinetic pressure − cohesion, and p_N and p_T are the pressures in the capillary layer respectively at right angles and parallel to its surface, whilst the S signify the corresponding cohesions, then $p_N - p_T = S_T - S_N$ and $\zeta = H/(S_T - S_N)$. Deducing the energy after Clausius-Sarrau (instead of after Laplace as previously), the author again arrives at ζ values in close agreement with his other values. The calculations are made for CO_2 and also for benzene and ether. H. B.

804. *Mode of Formation of Dust-Figures on Walls and Ceilings.* **C. B. Bazzoni.** (Frank. Inst., J. 189. pp. 499–506, April, 1920.)—The author describes simple experiments made to determine the cause of the dust-figures which occur on walls and ceilings, frequently outlining laths and other underlying structures. Using a chamber 70 × 30 × 20 cm., it is found that dust-figures produced on its ceiling can be divided into two classes. Those of the first type, of which the most common figure is that showing up the laths and beams under the plaster, are produced only in the presence of moisture; any cold area of the surface, formed by a more rapid flow of heat through the ceiling, causing a deposition of water to which the dust adheres. The second type appears only at the edge of mouldings or other obstructions which impede the flow of ordinary ventilation currents. The carrying capacity of the air stream is less with its velocity reduced and dust is deposited. To obtain these figures upon a ceiling water-vapour is also necessary to render the ceiling sticky, otherwise the dust settles downwards. Such figures may be obtained in dry air upon the floor. T. H.

805. *The Nuclei of Atoms and the New Periodic System.* **W. D. Harkins.** (Phys. Rev. 15. pp. 73–94, Feb., 1920.)—*Structure of atomic nuclei; helium-hydrogen hypothesis.* The present paper is a summary and extension of previous articles by the author on this subject. Besides the direct evidence afforded by radio-active transformation and by the disruption of atomic nuclei by alpha rays, the data upon which any theory of nuclear structure must be based are atomic masses, atomic numbers which are supposed equal to nuclear charges, and atomic stabilities which are supposed to be related to the relative abundance of the elements in nature. Now the fact that the atomic weights of the 27 lightest elements and of the radio-active elements are approximately integers and that the difference in atomic weight between elements whose atomic numbers differ by a multiple of 2 is usually a multiple of 4, suggests that the nuclei of these elements are built up of hydrogen and helium nuclei. *Assuming* (1) that the nuclei consist only of helium nuclei (α), hydrogen nuclei (η) and electrons (β); (2) that the mass of a nucleus is very nearly equal to the sum of the masses of its constituents; and (3) that the number of hydrogen nuclei, except as combined to form helium nuclei, is never more than 3 (except when the mu (μ) group ($\eta_2\beta_2$) characteristic of isotopes is also present), the *formulæ for the composition of each of the nuclei of the first 27 elements and of the radio-active elements* may be determined from the atomic weights and the atomic numbers. These formulæ are given in Tables II and III in the original paper. Remarkable regularities are found. With the exception of beryllium ($\alpha_2\eta\beta$) all the atomic nuclei of the *even-numbered light elements* seem to consist merely of helium nuclei, with a pair of cementing electrons added in the case of the higher numbers; while the *odd-numbered light elements*, except nitrogen ($\alpha_3\eta_2\beta$) and scandium ($\alpha_{11}\beta$ or more probably $\alpha_{11}\eta\beta_2$) differ from even elements only by each containing an additional group ($\eta_3\beta_2$). The fact that the odd elements are much less abundant in nature than corresponding even elements suggests that odd light elements are less stable, due presumably to the added group $\eta_3\beta_2$. If this group exists as a separate atom, it is an isotope of hydrogen with an atomic weight 3 and may be the hypothetical *nebulium*. It is suggested that this group $\eta_3\beta_2$ and the helium nucleus, assumed to have the composition $\eta_4\beta_2$, each consist of two ring- or disc-shaped electrons with respectively three and four hydrogen nuclei arranged symmetrically between them. The *stability* of various atomic structures is discussed on the basis of the formulæ. It is pointed out that *binding and cementing electrons* usually occur in pairs; there are, however, several exceptions. As for the *radio-active elements*, the corresponding elements of the thorium and uranium series differ in weight by 2 units and their formulæ are alike except for the presence of the additional group $\eta_2\beta_2$ or μ group in each element of the uranium series. The latest determinations of the atomic weights of these elements indicate that they are all approximately integers and that the loss of mass due to packing in the nuclei is very small. Why the *elements with numbers from* 28 *to* 80 do not fall in with this scheme can be explained only by assuming that in most cases they consist of mixtures of isotopes. Chlorine, silicon, magnesium, and neon, among the light elements are also mixtures of isotopes. The conclusion from all of the above is that the hydrogen nucleus is the positive electron. In a note appended at the time of correcting the proof for this paper, the writer states that his latest atomic-weight results seem to indicate that he has obtained *an experimental separation of chlorine into isotopes. This is the first separation of an element into atomic species which has ever been obtained experimentally.* AUTHOR.

806. *Do Simple Numerical Relationships exist between the Linear Dimensions of the Atoms?* **M. Pierucci.** (N. Cimento, 19. pp. 109–115, March, 1920.)—On the assumption that only at the absolute zero of temperature is it possible for the atomic volume to represent the true volume of the atoms, the author calculates the cube root of the atomic volume at absolute zero for those elements which (1) have a known density in the solid state, and (2) have a coefficient of thermal expansion which either is known at low temperatures or is known and very small at ordinary temperatures. To this cube root he gives the name atomic radius. The necessary data are taken from Landolt's Tables and are known, in some instances only approximately, for 29 elements. The results obtained appear to suggest that the atomic radii of all elements are integral multiples of one and the same length. T. H. P.

807. *The Helium Atom.* **A. Landé.** (Phys. Zeits. 21. pp. 114–122, March 1, 1920.)—In a previous paper [Abs. 1043 (1919)] the author has shown that the quantum theory may be used to explain the series spectrum of helium. The helium atom was assumed to consist of a positive nucleus with charge $+2e$, around which two electrons revolve in circular or elliptical paths. In the present theory a more exact perturbation theory is presented, whereby some of the results previously deduced are confirmed, while others are corrected. A. W.

808. *The Electronic Ring Model and the Electrical Moment of some Dipole Molecules.* **L. Schames.** (Phys. Zeits. 21. pp. 156–158, March 15, 1920.)—The author has previously shown that the moment of inertia calculated from the chemical constants is in complete accord with that derived from the ultra-red absorption spectrum, and also, at least for N_2, with that given by Laski [see Abs. 1309 (1919)] based on the increase of the specific heat deduced from the electronic-ring model. The author now considers an analogous case for the dipole molecule. Starting from

the moment of inertia, the distance apart of the nuclei may be derived, following which the distance of the nuclei from the plane of the electronic ring may be calculated from the electrostatic condition of equilibrium, and finally the radius and angular velocity from the quantum hypothesis. The electric moment then follows from the molecular constitution so found. Debye has also derived this quantity from his theory of the temperature dependence of the dielectric constants [see Abs. 971 (1912)]. Comparison shows that the moment as calculated here is too great. The author opines that the cause of this deviation may be due to electronic motion in a spacial orbit, instead of plane rings, similar to that proposed by Born for the electrons of the ions of certain simple crystals. This point of view is reserved for a later article. The paper concludes with an application of the theoretical results obtained to the estimation of the electric moments and dimensions of CO, HCl, H_2O, and CO_2.

H. H. Ho.

809. *Constitution of Atmospheric Neon.* **F. W. Aston.** (Phil. Mag. 39. pp. 449–455, April, 1920.)—Suggestions as to the complex nature of atmospheric neon were made in 1912 by J. J. Thomson, who obtained positive-ray photographs indicating elements of atomic weights of 22 and 20. This evidence, combined with other observations, led the author to undertake a searching investigation on the constitution of the gas by two distinct methods: firstly by direct separation and secondly by positive-ray analyses.

Diffusion experiments by Lindemann and the author gave a negative result, no separation of the "constituents" of neon being obtained. It has recently been shown [Lindemann, Abs. 1244 (1919)] that this negative result was theoretically inevitable. Further experiments more recently with more elaborate apparatus gave positive, but inconclusive, results.

The evidence of positive-ray analysis by a very accurate method recently developed by the author has yielded very definite results. The evidence is based on three methods of analysis of the positive-ray records: (1) the character of the lines, (2) their position, and (3) their intensity. The results indicate clearly that neon is a mixture of isotopes. Mass-spectra obtained by means of the positive-ray spectrograph are shown, measurements from which prove conclusively that neon contains two isotopes having atomic weights 20·00 and 22·00, respectively, to an accuracy of about 0·1%. The proportions of these two isotopes is in the ratio of 90% to 10% by volume. On the clearest spectra obtained with neon there are distinct indications of a line corresponding to an isotope of mass 21. This line is extremely faint, so that if this constituent exists its proportion would be very small, probably well under 1%.

A. B. W.

810. *A Model for Demonstrating Crystal Structure.* **H. P. Whitlock.** (Am. J. Sci. 49. pp. 259–264, April, 1920.)—The model may be readily put together and taken apart while the demonstrator is speaking, is plainly visible to a fairly large audience, and by using interchangeable rods may be employed to demonstrate and study any point system of atomic spacing.

E. A. O.

811. *The Lateral Vibrations of Sharply-pointed Bars.* **J. W. Nicholson.** (Roy. Soc., Proc. 97. pp. 172–181, April 15, 1920.)—Mathematical.

812. *The Gyroscopic Compass: a Non-mathematical Treatment.* (Engineer, 129. pp. 55–57, Jan. 16; 81–83, Jan. 23; 105–107, Jan. 30; 136–138, Feb. 6; 160–162, Feb. 13; 210–212, Feb. 27, and pp. 242–245, March 5, 1920.)

813. *Two-dimensional Flow of Liquid between Plane Parallel Walls.* **G. Jaffé.** (Ann. d. Physik, 61. 2. pp. 173–194, Jan. 15, 1920.)—An entirely mathematical treatment on the lines of Karman's work [Abs. 294 (1912)]. L. H. W.

814. *The Principle of Relativity.* **Langevin.** (Soc. Franç. Élect., Bull. 9. pp. 601–639, Dec., 1919.)—A summary of the present state of our knowledge on this subject. L. H. W.

815. *The Structure of Matter and the Quantum Theory.* **F. H. Loring.** (Chem. News, 120. pp. 181–184, April 16; 205–207, April 30, and pp. 217–219, May 7, 1920.)—Discusses recent work bearing on this subject and puts forward the author's own views. [The original pages should be referred to by those interested.] L. H. W.

816. *Structure of the Atmosphere when Rain is Falling.* **V. Bjerknes.** (Roy. Meteorolog. Soc., Quarterly J. 46. pp. 119–138; Disc., 138–140, April, 1920.)—The ascent of air necessary to produce rain may be caused (1) by the effect of topography, (2) by the convergence of air currents. The first produces a stationary rain area, the latter in general a moving system. The convergence is revealed by drawing the lines of flow from wind observations. Three cases are considered: (*a*) a line of convergence along which a warm moist current is commencing its ascent over a colder one lying across its path and which it gradually pushes back, (*b*) one along which a cold current is replacing a warm one, pushing under it and lifting it up, (*c*) a point of convergence of air streams due to local heating. (*a*) and (*b*) produce travelling rain fields and one of each is associated with a typical cyclone; (*a*) is related to the direction of motion of the cyclone and is named by the author the " steering line "; (*b*) is the " squall line "; (*c*) is the case of summer showers and thunderstorms. A number of diagrams illustrating the several cases are given. In the *discussion* **N. Shaw** said there is reason to think that the discontinuities in a cyclone represented by the " steering " and " squall " lines are peculiar to the surface layers and do not exist above about 2 km. **C. Salter** hoped attention might be directed to the amount and intensity of rain in the differing circumstances producing it. M. A. G.

817. *Winds and Temperature at High Levels.* **V. Bjerknes.** (Comptes Rendus, 170. pp. 604–606, March 8, 1920.)—Shows that the observed predominance of upper westerly winds is consistent with the observed temperature gradients. If the earth and atmosphere be treated as a rotating system symmetrical about the earth's axis, then " level " surfaces are represented by the differential equation $dy/dx = -X/Y + x\Omega^2/Y$, and " isobaric " surfaces by $dy/dx = -X/Y + x\omega^2/Y$, where Ω is the angular velocity of the earth, $\omega(x, y)$ that of the air distant (x) from the axis and (y) from the equatorial plane, and $-X$, $-Y$ are the components of the earth's attraction at this point perpendicular and parallel to the axis. Thus if $\omega = \Omega$ level and isobaric surfaces coincide. The condition for westerly winds is $\omega > \Omega$, whence from the above equations the isobaric surface makes a smaller acute angle with the equatorial plane than does the level surface. Thus at these heights the isobaric surfaces may be likened to ellipsoids more eccentric than the level surfaces. However, by considering possible outer boundary conditions of the atmosphere it is argued that the isobaric surfaces must become less eccentric again at greater heights. It follows that the "thickness" of the lower layers between successive isobaric surfaces decreases from equator polewards and hence the temperature decreases in this direction, while in the upper layers the reverse holds and temperature increases polewards. This agrees with observation. M. A. G.

818. *Internal Friction in the Atmosphere.* **D. Brunt.** (Roy. Meteorolog. Soc., Quarterly J. 46. pp. 175–184; Disc., 184–185, April, 1920.)—Assuming that the coefficient of eddy-diffusion (K), the pressure gradient, and the density of the air do not vary with height, that the motion is steady and that at the surface the direction of slipping is in the direction of strain, the author first finds the manner in which the wind approaches the geostrophic wind with increasing height [see Abs. 518 (1920)]. If R denote the frictional force per unit volume and β its inclination at the surface to the reversed wind direction, the theory demands that $\beta=45°$. This is used to test the theory for R, and β may be deduced independently of the theory from quantities which may be observed. Taking mean values obtained by a number of writers the agreement with the theoretical value is not found to be good. The assumptions made are examined and it is concluded that the chief cause of the discrepancy is that K varies with height (z). Solutions are obtained for the cases $K \propto z^2$ and $K \propto z^4$ taking $R=K\varrho\partial^2 v/\partial z^2$. In the *discussion* **F. J. W. Whipple** and **M. A. Giblett** thought it probable this should be written $R=\partial/\partial z(K\varrho\partial V/\partial z)$, where V is the vector representing the wind, and ϱ the density of the air. M. A. G.

819. *Atmospheric and Terrestrial Radiation.* **W. H. Dines.** (Roy. Meteorolog. Soc., Quarterly J. 46. pp. 163–171; Disc., 171–173, April, 1920.)—An estimate is made of the atmospheric and terrestrial radiation crossing any level surface in the atmosphere which for the purpose is divided into 10 layers of equal mass each contributing 100 mb. to the total pressure. The radiation emitted by each layer is assumed to be $\eta\sigma T^4$, where σ is Stefan's constant, T the absolute temperature and η a constant, while of that entering a layer the fraction η is absorbed and $1-\eta$ transmitted. The value of η is uncertain and varies with the mass of the layer, the humidity, and amount of cloud in the layer. For a layer of dry air one-tenth of the mass of the atmosphere L. F. Richardson gives the value 0·23. The calculation is simple and the result is given for 13 distributions among the 10 layers of values of η ranging from 0·10 to 0·90, taking for T the mean values over England and treating the earth as a black body radiating at 283° abs. (the mean temperature of the ground in south-east England). It is found that the same general result follows from all the distributions of η, (1) that the strata up to 400 mb. are losing heat by radiation, (2) from 400 mb. to 200 mb. gaining, (3) above 200 mb. losing. There is, however, no systematic change of temperature, the losses being made good in (1) by latent heat of condensation and solar radiation mainly through contact with ground, and in (3) by solar radiation, while in (2) the gain is balanced by loss due to mixing. A tropical distribution of temperature gives similar results but no loss in the top layers as in (3), while comparing cyclone and anticyclone more heat appears to be radiated in the former. The facts that the absorbing power of air may be selective and that part of the earth's radiation may be reflected back are neglected and it is thought that this does not seriously modify the results. Amongst other quantities estimated is the radiant energy leaving the earth at the top of the atmosphere, the result agreeing well with the mean value for the earth given by Abbot and Fowle. In the *discussion* **E. Gold** suggested the calculation should be done for values of η 10 or 100 times as great in the lowest layers as at the top. **N. Shaw** wondered if an average transference of air from a place of higher mean temperature should be considered as helping to make good the losses in (1) and (3). M. A. G.

820. *Experimental and Theoretical Investigation of Aureola Phenomena in Homogeneous Fog.* **R. Mecke.** (Ann. d. Physik, 61. 5. pp. 471–500, March 3, 1920. Dissertation, Marburg, 1919.)—In the introduction to this dissertation a general discussion is given of diffraction phenomena in homogeneous fog, of which three kinds are possible when the fog is regarded as composed of equal-sized transparent drops behaving as spherical lenses. The first is that of the rainbow and is produced by internal reflection in the drops; the theory is based on the diffraction of non-spherical waves and has been worked out by Airy, Pernter, and Mobius [see Abs. 1704 (1910)]. A second phenomenon known as halo is only visible in reflected light and gives rise to such effects as that observed on the Brocken. An explanation, though incomplete, of this halo effect has been put forward by Richarz. The present author acting on a suggestion of Richarz failed, however, to produce the halo effect when an intense arc light was passed through a whirl of lycopodium dust, although this is visible with an artificial fog in weak diffused daylight. It appears therefore that other causes intervene which are probably dependent on the property of the drops as spherical lines. The third phenomenon is produced by transmitted light and is manifest in the form of coloured corona also termed aureola or small haloes when thin cloud or fog obscures the sun or moon. The object of this paper is to investigate and explain this phenomenon and its variations. Section 2 deals with fog formations and the dimensions of the drops. The experimental arrangements used are very fully described. Following this comes an experimental investigation of the diffraction phenomenon in homogeneous light. This chapter is divided into 5 sections as follows:—(1) Influence of the thickness of the fog layer; (2) Investigation of the diffraction pattern in white light; (3) Measurements in monochromatic light; (4) Experiments with homogeneous fogs produced from other liquids than water, *e.g.*, alcohol, ether, chloroform, benzol, toluol, aniline; (5) Comparison experiments with spores and drops of sulphur in order to eliminate the effects of transparency. The diffraction phenomena exhibited by homogeneous fog in transmitted light can only be explained on the diffraction theory for a drop radius of up to 5–4μ. With smaller drops in white light other phenomena occur; the central field which has remained white up to this point now becomes intensively coloured and resembles the colours of thin films. The light source itself generally takes a complementary colour with a dense fog. The colour sequence in the rings has not yet received explanation. In monochromatic light, the diffraction patterns exhibit special arrangements of maxima and minima which distinctly possess a periodic character. A determination of the drop dimensions from the diameter of the ring was not found possible. The deviations decrease with increase in size of drops, and the diffraction pattern gradually approaches normality. Any influence of thickness of fog layer on these phenomena cannot be established. From experiments with other liquids it is found that the transparency of the drops contributes to the formation of anomalous diffraction patterns, these being more pronounced the greater the refractive index.

H. H. Ho.

821. *A Single General Explanation of Appearances of Atmospheric Polarisation.* **M. A. Schirmann.** (Ann. d. Physik, 61. 2. pp. 195–200, Jan. 15, 1920.)—This is a theoretical paper, based on the results obtained in previous work [see Abs. 1502 (1919)], in which it is sought to explain solely for foreign-body particles in the atmosphere from their magnitude and optical behaviour when all secondary diffusion of light is excluded, all the phenomena of atmospheric polarisation in a qualitative sense. On the ground of the theory here put forward it is concluded that the electromagnetic refraction theory is alone able to explain in a complete manner all the problems of atmospheric polarisation from the magnitude and optical behaviour of the disturbing particles in the atmosphere. A qualitative solution of all problems of meteorological optics, in which the atmosphere plays the part of a muddy medium, would only become possible if the diffusion and absorption for the special kinds of particles (water drops, dust particles, etc.) were numerically determined.

A. E. G.

822. *Oceanic Temperatures and Circulation.* **G. F. McEwen.** (Misc. Studies Univ. of California, Publ. pp. 335–421, 1868–1918.)—The relation between oceanic temperature and solar radiation when there is no flow is first studied. The sum of the rate of gain of heat and the rate of loss of heat from a small volume of water at a given latitude and depth equated to the product of the volume by the specific heat and by the rate of temperature change gave a differential equation, whose solution determined the temperature from the surface to a depth of 10 metres. The constants were determined from statistics relating to surface temperature and solar radiation. The lag between the temperature maxima and minima and the times of radiation maxima and minima deduced from these constants agreed well with observed values. The rate of change of temperature due to some other factor can be obtained by adding another term to this differential equation. The solution of the equation so modified gives the temperature due to the new factor. In this way the temperature due to a given horizontal current was determined. Numerical applications of this formula to a region of the North Pacific off the California coast and of the North Atlantic off the African coast gave estimates of the horizontal flow in good agreement with the direct observations. Investigations were also made into upward directed currents. Observations in deep water 20 miles offshore from San Diego were sufficient to determine approximately all the constants, including the velocity of upwelling and the term corresponding to the conductivity. This has been called the *eddy conductivity* and was found to be several thousand times the laboratory value. Salinity observations, though not so complete, confirmed the conclusions. The eddy conductivity is not a physical constant of the substance, but depends on the intensity and character of the circulation. W. A. R.

823. *Worldquakes and Long Waves.* **K. Mack.** (Phys. Zeits. 21. pp. 7–11, Jan. 1, 1920.)—The author states that an earthquake that permits of the determination of the presence of W_2 or W_3 waves in the seismogram of any observing station is to be considered as a worldquake. The decision as to whether an earthquake is a worldquake is most simply and quickly arrived at by looking for the W_3 waves; if these are not present, the W_2 waves should be looked for. If the epicentre be known the position in the seismogram of the W_2 waves can easily be found. If the epicentre be not known, the W_2 waves can generally be found on searching and an approximate value of the epicentre arrived at. The W_4 waves, which are due to the wave once again passing around the earth's periphery, can only seldom be definitely observed. Waves of still higher order have not as yet been observed. Some general formulæ are then given which allow of the distance of the epicentre and the velocity of propagation of the surface waves being calculated from the observed times of arrival of the W_1, W_2, W_3, etc., waves at a certain station. An investigation is made of the exceptionally strong worldquake of 1917, June 26. A good seismogram was obtained of this at the Hohenheim earthquake observatory with the Mainka type of bifilar pendulum. The results are briefly as follows:—The W_1 waves show very markedly on the seismogram. Eight maxima can be distinguished, the 5th being the greatest. This can be called $M_{1,5}$, the first suffix showing the relation to the W_1 waves. The region in which these 8 maxima were found is termed the core of the W_1 waves; and it was sought to make certain that this core recurred in the W_2, W_3, and W_4 waves present in the seismograms. This was definitely confirmed in the case of the W_2 and of the W_3 waves, and with great probability for the W_4 waves. It was possible, in the three further core regions, to determine the position of the chief maximum, designated $M_{2,5}$, $M_{3,5}$, $M_{4,5}$ respectively. The value finally arrived at for the distance of the epicentre, Δ, is 16,600 km., and for the velocity of propagation, V, the value 3·35 km. per sec. L. H. W.

824. *The Earth's Density and Rigidity.* **W. D. Lambert.** (Washington Acad. Sci., J. 10. pp. 122–143, March 4, 1920.)—This paper is a semi-popular account of the present position with respect to the rigidities and density of the earth. W. A. R.

825. *Deflection of Light by Sun's Gravitational Field. Total Eclipse of May* 29, 1919. **F. W. Dyson, A. S. Eddington,** and **C. Davidson.** (Roy. Soc., Phil. Trans. 220. pp. 291–333, April 27, 1920.)—The main purpose of the expedition was to attempt definitely to decide between three alternatives—(1) Path of light not influenced by gravitation; (2) light-energy subject to ordinary gravitation. If by Newtonian law, star close to limb should be displaced outwards by 0·87″; (3) light travels according to Einstein's generalised relativity theory, and the displacement will be twice this, *i.e.*, 1·75″ outwards. A sketch is given of the result of previous attempts to decide the question, and a full account of the expeditions to Sobral and Principe (equipment, *personnel*, weather conditions, and so on), including the precautions found necessary or

advisable to ensure accurate scaling of the plates. The astrographic telescope taken to Sobral unfortunately yielded inferior results, attributed to temperature effects on the cœlostat mirror, but the photographs taken with the 4-in. telescope gave a much better result, the adopted mean being 1·98″ ± 0·12″. At Principe clouds interfered, and the result came out 1·61″ ± 0·30″. Even the Sobral astrographic plates gave 0·93″ with a large probable error. So that on the whole Einstein's theory is strongly supported. There were no stars close to the limb, so the displacements measured were not large, but the subjoined table gives the radial displacements of seven of the stars shown on the plates taken with the 4-in. at Sobral, compared with those calculated by Einstein's theory.

Star.	Calculation.	Observation.
	″	″
11	0·32	0·20
10	0·33	0·32
6	0·40	0·56
5	0·53	0·54
4	0·75	0·84
2	0·85	0·97
3	0·88	1·02

It is considered desirable to repeat the test at the earliest opportunity, but the stars will be fainter and further from the limb. Probably the astrographic telescope will be used with an equatorial mounting, doing away with the cœlostat, and with the object-glass stopped down to 8 in.

W. W. B.

826. *The Larger Opportunities for Research on the Relations of Solar and Terrestrial Radiation.* **C. G. Abbot.** (Nat. Acad. Sci., Proc. 6. pp. 82–95, Feb., 1920.)—For fifteen years the solar radiation as measured by the Smithsonian Astrophysical Observatory at Mt. Wilson and elsewhere has shown short-period variations. These have been compared with terrestrial temperatures and pressures and appear to be of importance in this connection. It is therefore desirable to make daily observations to determine the variation and also to find the exact influence on terrestrial phenomena. A minimum of four stations in the most cloudless regions of the earth is required for the first object, one such being already in existence at Calama, Chile, maintained by Smithsonian funds. Autographic records of cloudiness, if such could be devised, would be of very great value. Pyrheliometer observations are wanted at many more stations than those at present equipped for the purpose. The outgoing radiation has been studied both in the shorter wave-lengths for which optical media are available, and also by means of the pyrgeometer and pyranometer for longer wave-lengths. Potassium iodide if it can be produced in large enough crystals appears likely to enable the longer wave-lengths of terrestrial radiation to be studied. Something remains to be determined as to the absorption of long wave-lengths by blackened surfaces. Ozone in the atmosphere must also be studied, as its effect on terrestrial radiation is at the wave-length of 10 μ where water-vapour is transparent.

After a full discussion of these matters the author gives an example of the variation of temperature at Buenos Aires following observed changes of the "solar constant" from day to day. He then states that as a result of experience at Calama, he considers that with a staff of three industrious and energetic persons it is possible to compute and send out the result of morning observations of a given day before nightfall. A brief empirical method has lately been devised at Calama which enables the result of a morning of observation to be telegraphed to the world by noon; and this should be of immense value in forecasting when the sequence of cause and effect is better understood. W. W. B.

827. *Gaseous Currents within the Sun.* **G. Gouy.** (Comptes Rendus, 170. pp. 638–642, March 15, 1920.)—The author is considering the possibility of convection currents within the sun, which has been denied by some on account of the assumed rigidity or viscosity of the mass of gas. He sets out to compare the probable viscosity with that of pitch. Experiment shows that the viscosity coefficient increased as the square root of the absolute temperature. Thus at 10^6 (degrees), air would have the ordinary viscosity of water, and at 10^9 half that of sulphuric acid. Temperature alone, then, will not produce very great viscosity. Pressure in so great a mass as the sun may have a much greater effect than is generally supposed. He considers the motion of a viscous fluid as governed either by hydrodynamical laws, if the chief effect of the force is to overcome the viscosity, or if this is not the case, by those of hydraulics. The first of these governs the deep layers of the sun, while the shallow vortices belong to hydraulics. Where the viscosity is too great to allow of small-scale movements, he thinks it need not prevent large-scale movements. He considers the case of a region within the sun of one-millionth of the total volume and rather denser than its surroundings. With plausible values he obtains a value for the viscosity, 110 million times greater than that of pitch. A rigid metal ball of 2 cm. diameter in such a medium would require 3 centuries to fall one micron ($\frac{1}{1000}$ mm.) under a force equal to that of gravity on the earth. He considers also the twisting effect under such conditions, and then proceeds to argue that in spite of the viscosity, which is great enough to prevent mixing of masses of different density, it is yet unable to prevent convection of heat. W. W. B.

828. *Dualist Cosmogony and Collision Theory of Stellar Formation.* **E. Belot.** (Comptes Rendus, 170. pp. 658–661, March 15, 1920.)—[See Abs. 210 (1920) and previous papers.] The author pushes further his distinction between the results of a cosmical collision of a gaseous sphere with an irregular nebula. The sun's slow period of 11 years, he suggests, is what is left of its primitive pulsation. Novæ are getting slower and their oscillations are decreasing, while Cepheids maintain their speed but have irregular oscillations. He tabulates the hypothetical effect of collisions of the first, second, and third order, according as they are in regard to the colliding sphere, polar or equatorial; and the various subclasses include major and minor planets, satellites, comets, planetary nebulæ, clusters, spiral nebulæ, and practically every form of celestial object. He is inclined to approach the Cartesian "vortices" rather than the Newtonian system. W. W. B.

829. *A Star with Large Proper Motion.* **F. Kromm.** (Comptes Rendus, 170. p. 799, March 29, 1920.)—In comparing the Bordeaux zones with Bessel's Zone catalogue, the author has found numerous stars with proper motion. The star B.D. + 9·2636°, of 9·1 magnitude, appears to have been overlooked hitherto, but its motion is nearly a second of arc annually. Comparison with Bessel's zone and with Leipzig and Toulouse places shows annual proper motion in R A − 0·0458″, in Decl. − 0·540″, with resultant 0·867″ in direction 231·5°. W. W. B.

830. *Parallax of Krueger* 60. **S. A. Mitchell.** (Astron. J. 32. pp. 177–179, April 8, 1920.)—This star having a large proper motion, parallax and orbital motion, was put on the parallax programme of the McCormick Observatory, and measures were taken not only of the principal star but of its companion and of a third star receding from it. The author derives a parallax of + 0·261″ for the principal star, a period of 50 years for the close pair, and a mass 0·42 of that of the sun for the combined mass. The ratio of the masses is not yet accurately known, and he considers another 25 years' observations will be necessary.
W. W. B.

831. *Photographic Measures of Krueger* 60 *as a Double Star.* **S. A. Mitchell** and **C. P. Olivier.** (Astron. J. 32. pp. 179–181, April 8, 1920.)—Olivier's measures of 95 double stars from McCormick photographs are now in the press. This paper contains a few measures in advance, compared with Barnard's micrometric measures as a test of the accuracy obtainable. Krueger 60 is an easy object, though the components are close for photographic purposes and the magnitudes unequal. There is no evidence of systematic error, and the measures of the photographs are quire as accordant as Barnard's. It will be possible to continue the measures through periastron. Those so far obtained agree in angle with one of Russell's orbits and in distance with the other, thus indicating a mean period of 50 years [see preceding Abs.]. W. W. B.

832. *Stellar Spectroscopy at Detroit Observatory.* (Detroit Observatory, Publ. 2. Nature, 105. p. 244, April 22, 1920. Abstract.)—This includes a study by **P. W. Merrill** of Class Md variable stars, tracing the changes of the spectra with brightness. His suggestion to account for the variation is a smoke-veil of Ca and other condensing gases in the upper regions of the star's atmosphere, which would confine the heat of the photosphere, until the accumulation of heat vaporised the smoke-screen, condensation again following the escape of heat. This is analogous to the solid crust " Geyser " theory, which, however, is now discounted, as the stars appear to be mostly " giants." Another study by **L. Hadley** deals with the orbit of ζ Ursæ Majoris, giving a period of 20·53644 days, eccentricity 0·518, and mass × $\sin^3 i$, 1·83 and 1·79 times that of the sun for the two components. Stebbins finds no evidence of light-variation.
W. W. B.

LIGHT.

833. *Dispersion of Air in Ultra-Violet.* **W. Traub.** (Ann. d. Physik, 61. 6. pp. 533–548, March 16, 1920. Dissertation, Tübingen.)—The absolute value of the refractive index of dry air free from CO_2 was determined as accurately as possible for the green mercury line. The result obtained was $(n - 1) \times 10^7 = 2932 \cdot 74$, and the fourth figure is considered to be definitely established. The measurements agree very well with those of J. Koch, but disagree with the results of Posejpal [Abs. 357 (1918)]. The dispersion of air was investigated as far as λ1854 Å.U. The observations lead to the following dispersion formula:

$$n - 1 = \frac{5517160 \times 10^{-8}}{199 \cdot 5534 - 10^{-8}\lambda^{-2}} + \frac{48803 \times 10^{-8}}{43 \cdot 8193 - 10^{-8}\lambda^{-2}}.$$

The dispersion methods agree very well with Koch's results throughout the whole spectral region investigated. A. W.

834. *Reflection and Transmission of Ultra-Violet Light by Sodium and Potassium.* **M. K. Frehafer.** (Phys. Rev. 15. pp. 110–125, Feb., 1920.)—*Reflecting Power of K and Na, for wave-lengths from* 0·25 *to* 0·55 *μ*. (1) *Normal incidence* (10°). *Opaque mirrors* in contact with fused quartz were tested with monochromatic light from a mercury arc. A sodium photoelectric cell was used to compare the intensities of incident and reflected beams. It was found that sodium maintains a remarkably high reflecting power throughout the ultra-violet, increasing slightly from a flat minimum near 3600 Å to 80% at 2536 Å. The reflecting power of potassium on the contrary decreases rapidly with the wave-length, reaching the very low value of 11% at 2536 Å. *A thin film of potassium* deposited and kept at − 190° C. gave a curve of the same form. Among the metals so far investigated in the ultra-violet, therefore, sodium and potassium have respectively the highest and lowest reflecting powers. (2) *Polarised light at* 45° *incidence.* The ratio of the reflecting powers for light polarised with the electric vector respectively parallel and perpendicular to the plane of incidence, was found for both sodium and potassium to have a maximum value near 3650 Å. There is also a common minimum at about 3341 Å. which is far more pronounced in the case of sodium.

Transmitting power of K and Na films for wave-lengths from 0·25 *to* 0·55 *μ*.—Films deposited on quartz and on glass at liquid-air temperatures were studied while still cold by the use of a special apparatus, and compared with the ordinary colloidal films prepared at room temperature. The results are shown graphically. Under comparable conditions, the transmitting power of potassium is considerably greater than that of sodium.

Thin films of K and Na deposited at − 190° *C.* on quartz have a metallic *appearance*; on being warmed a thin film becomes peppered with holes and an opaque film loses its lustre. AUTHOR.

835. *Displacement of the Reflection Maximum towards the Position of Special Frequency.* **K. Försterling.** (Ann. d. Physik, 61. 6. pp. 577–

584, March 16, 1920.)—For knowledge of the structure of a polyatomic crystal an important quantity is the frequency of the atomic vibrations in the molecular union. The effect of these oscillations is best observed by optical means, since the reflectivity attains especially large values in the neighbourhood of the special oscillation. By means of Rubens' residual-ray method the max. reflectivity for a series of substances has been determined. A quantitative calculation of the displacement of the reflection maximum with respect to the special frequency has hitherto proved impossible on account of the great complexity of the respective formulæ, and the present author has now put forward a simplified solution. Section 1 evolves the fundamental equations for reflection and dispersion. Section 2 investigates the reflection maximum. In section 3 application is made to diatomic crystals, while section 4 is devoted to fluorspar. Very good agreement is found between the observations as given by the Rubens method, the frequencies obtained from the specific heat theory, and the values calculated by Born from the dimensions of the dielectric constants in conjunction with other optical data.

H. H. Ho.

836. *Reflectivity of Aluminium Alloys.* **R. G. Waltenberg** and **W. W. Coblentz.** (Bureau of Standards, Bull. 15. pp. 653–657 [Sci. Papers, No. 363], 1920.)—Describes the preparation of different alloys of aluminium with magnesium and zinc. All these alloys were found to tarnish in time, so that they could not be used for permanent mirrors. The best in this respect was the compound Al_3Mg_4, and for this alloy a reflectivity of 92% was obtained at 0·7 μ. The zinc alloy was found to have a minimum reflectivity at 0·9 μ and a similar minimum was found for pure zinc at 1 μ.

J. W. T. W.

837. *Colourimeter Design.* **H. Hartridge.** (Cambridge Phil. Soc., Proc. 19. pp. 271–282, Feb., 1920.)—The discussion of the subject here given leads to the following conclusions :—(1) The comparison field seen on looking down the instrument should cause the greatest contrast, and at the same time should not produce after-images. (2) On both limbs of the instrument double troughs should be used, so that the thickness of pigment to be measured may be varied at will, while the absorption caused by other pigments remains constant. (3) An artificial light source should be used, and the lighting system be so designed that narrow beams are produced of width just sufficient completely to illuminate the comparison field. The amount of reflected and scattered light may thus be reduced to a minimum. (4) If experiment shows that the change in colour produced by a given change in thickness or concentration of the pigment can be increased by modifying the relative intensity of different parts of the spectrum of the light source, then suitable colour-filters should be prepared for use during the determinations. It was found in a test case that this modification alone increased the accuracy by three times. (5) The general design of the instrument should conform to microscopic practice, fixed troughs being supported by the stage and the movable trough actuated by the rack-and-pinion coarse adjustment screw. The illuminating system should be fitted beneath the stage so that the instrument may be tilted or moved from place to place without disturbing the alignment.

A. W.

838. *Modification of Jamin's Interferometer.* **U. Doi.** (Phys. Math. Soc. Japan, Proc. 2. pp. 38–42, March, 1920.)—Theory of the instrument is first given, and expressions are obtained showing how the characteristics of the fringes depend on the variables involved. A modified form of apparatus is described in which a right-angled prism is used instead of a second plate, the first plate and its image in the prism (regarded as a pair of plane mirrors at right-angles) playing the *rôle* of the two plates of Jamin's interferometer. Using a telescope focused for parallel light the fringes are easily obtained with one of the reflecting faces of the prism nearly parallel to the plate, and appear as regular and parallel fringes parallel to the right-angled edge of the prism. The fringes are easily regulated to suit different experiments by adjusting the inclination of the prism relative to the plate. A. W.

839. *Coherence in Wide-Angled Beams of Light.* **E. Schrödinger.** (Ann. d. Physik, 61. 1. pp. 69–86, Jan. 8, 1920.)—This paper gives theory and describes experiments with incandescent metal filaments which show that a series of secondary waves issue from such filaments, and that when the radius of the wire is comparable with the wave-length of the light the intensity of the secondary waves has an appreciable order of magnitude. No coherence can be detected between the secondary radiation and the primary beam. [See Abs. 654 (1917).] A. W.

840. *Spherical Aberration of a Symmetrical Optical System.* **T. Y. Baker** and **L. N. G. Filon.** (Roy. Soc., Phil. Trans. 221. pp. 29–71, 1920. Roy. Soc., Proc. 97. pp. 196–198, April 15, 1920. Abstract.)—Establishes an empirical formula for the longitudinal spherical aberration of rays which traverse a symmetrical optical system in an axial plane. This formula is of the type $At^2/(1 + Bt^2)$, where t is the slope of the emergent ray calculated by Gauss' method, A is the usual coefficient of first order aberration, and B is another coefficient of the third degree in the magnification. This formula is shown to be correct as far as the second order, inclusive, for a single refracting surface. For a single lens there is an additional term Et^4 in the numerator, but this term is of slight importance for a single lens in most cases. A similar formula is found for the sine ratio, viz., $\sin \alpha_0/\sin \alpha = M(1 + C't^2)/(1 + Bt^2)$, where M is the paraxial sine-ratio and $t = \tan \alpha_0/M$. This formula also holds as far as the second order for a single refracting surface. J. W. T. W.

841. *Diffraction of a Telescope Objective in the Case of a Circular Source of Light.* **H. Nagaoka.** (Astrophys. J. 51. pp. 73–102, March, 1920).—*Diffraction of a telescope objective; distribution of intensity in the image of a circular object and of a combination of circular objects.*—Many astronomical observations involve the question of the effect of diffraction on the images of circular objects. This problem is exhaustively treated in this paper. After deriving the general expression for the intensity of any part of the image of a circular source, in the form of an integral of a combination of cylinder functions and elliptic integrals, the author evaluates it for various parts of the image: the centre, the periphery, and points just inside and outside the periphery. The results obtained for the intensity near the periphery, called the marginal intensity, are of particular interest. They enable diagrams to be constructed which show the isophotes for various stages of the following phenomena:

(1) the transit of a bright point over a bright disc; (2) the transit of one bright disc over another; (3) the transit of a dark disc over a larger bright one. The isophotes of a *luminous lune* are also given.

Telescopic observations of transits; effect of diffraction phenomena.—The diagrams just mentioned show (1) that a luminous point approaching a luminous disc appears to enter the disc before it really is in line with the periphery, and (2) that the moment of contact of two discs is difficult to judge on account of the gradual transition of the isophotes. In the case of such occultation and transit phenomena, therefore, the time observations may vary with the instrument used. AUTHOR.

842. *Chromatic Variation of Spherical Aberration in Cemented Doublets.* **[Miss] L. M. Gillman.** (Optical Soc., Trans. 21. 2. pp. 53–64; Disc., 64, 1919–1920.)—Describes calculations of the intersection lengths of paraxial and marginal rays for series of cemented telescope objectives having surfaces of slightly varying curvatures. It is shown that these may be plotted as curves which show a remarkable uniformity throughout the series. The shape of the curves is nearly parabolic, and it is shown that the angle between the paraxial and marginal curves is practically constant, while the curvature of the marginal curve is greater than that of the paraxial in a constant ratio. Hence the curves for any lens in the series can be predicted from a knowledge of both paraxial and marginal curves of one other form. The best results correspond very closely with the objective determined by algebraic calculations in which the thickness is neglected. J. W. T. W.

843. *Correction of Astigmatism in Single Lens with Stop.* **T. Y. Baker.** (Optical Soc., Trans. 21. 2. pp. 65–75, 1919–1920.)—An investigation of the positions for which correction of first order astigmatism is possible when there is choice of the shape of the lens and of the position of the stop. The results obtained are exhibited in the form of a diagram. A short investigation is added of the extension to a system of lenses. J. W. T. W.

844. *New Method of Spectrophotometry in the Visible and Ultra-Violet Regions, and the Absorption of Light by Silver Bromide.* **R. E. Slade** and **F. C. Toy.** (Roy. Soc., Proc. 97. pp. 181–190, April 15, 1920.)—A quantitative investigation of the absorption of light by silver bromide has been undertaken as a preliminary to a photochemical investigation of the action of silver bromide in the photographic dry-plate. A good summary of the advantages and disadvantages of the various methods which have been devised by different experimenters for the quantitative investigation of the absorption of light by substances is due to Ewest, an abstract of whose work has been given by F. F. Renwick [see Abs. 843 (1914)]. All the methods which have been used previously either depend upon Schwarzschild's law of the relation between time of exposure and the photographic effect, or a so-called neutral wedge is used which is supposed to absorb equally in all wave-lengths or is calibrated for selective absorption. The method here described is in some ways similar to that used by Ewest, but the apparatus required is very much simpler, and a wedge of the material under examination is used instead of the neutral wedge of Ewest. In this method all that is required of the photographic plate is that the exposure of two adjacent portions of the same plate to the same light intensity of the same wave-length for the same time shall give the same density under identical conditions of development. This condition is easily satisfied, and errors are reduced to errors in measurements of length. The theory of the method is given in detail and the main part of the paper deals with the extinction coefficient of silver bromide. A. E. G.

845. *Figured Surfaces for Optical Systems.* **A. E. Conrady.** (Roy. Astron. Soc., M.N. 80. pp. 320–328, March, 1920.)—Discusses in full the advantages to be obtained by the use of figured surfaces in the design of optical instruments, and shows that the only direct effect of the departure from spherical surfaces is the control obtained over spherical aberration. This allows other conditions to be satisfied in a more desirable manner, *e.g.*, with smaller separations between separated components, and sometimes it may enable the designer to save one or two component lenses, or to eliminate an air-gap altogether and so secure greater light-transmitting power and a diminution of doubly-reflected false light. Owing to technical difficulties it is unlikely that heavy figuring will be practicable, and there will also be the extra difficulty of centring the figuring with reference to the optical axis of the finished instrument. J. W. T. W.

846. *Photographic Rendering of Tone Values.* **L. A. Jones.** (Frank. Inst., J. 189. pp. 469–484, April, 1920.)—The primary object in making a photograph is not in most cases the exact reproduction of the brightness and contrast of the original, but rather the production on a flat surface of variations in reflecting power such that the subjective impression obtained when this surface is viewed under a specified illumination will be as nearly identical as is possible with that produced in the mind of the observer when viewing the objects photographed. In this article the various steps in the photographic process are traced and the factors which affect the objective photographic rendering explained, the discussion of the subjective phase being entirely ignored. The factors of importance in tone production may be classified as those dealing with the distribution of light and shade in the subject, the translation of the tones of the subject in the making of the negative including the effect of exposure and development, the scale of printing papers, and the translation of the scale of the negative into the scale of the print, and, finally, the accuracy of the entire reproduction itself, as shown by a direct comparison of the print with the original subject. The last step in this process will be dealt with in a later paper; the present paper is intended to form an introduction to the elementary theory of the subject and deals with it along the following lines:—Distribution of light and shade in the subject; translation of the tones of the subject into the opacities of the negative; effect of development upon the scale of the negative; printing paper. A. E. G.

847. *Double Refraction.* **E. Henriot.** (Ann. de Physique, 13. pp. 5–25, Jan.–Feb., 1920.)—This paper gives a fuller treatment of the subject matter of a previous paper [Abs. 344 (1920)]. A. W.

848. *Colorimetric Experiments.* **V. O. Meissner.** (Phys. Zeits. 21. pp. 159–162, March 15, 1920.)—Further tests of colour-filters, prepared by Ostwald [Abs. 97 (1920)], and also of the purity of the colours of the *Farbenfibel.* Doubts are expressed as to the Weber-Fechner rule that the mean errors increase with the brightness. H. B.

849. *Radiation from a Perfectly Diffusing Circular Disc.* I. **J. W. T. Walsh.** (Phys. Soc., Proc. 32. pp. 59–70; Disc., 70–71, Feb., 1920.)—An expression is obtained for the amount of flux received from a perfectly diffusing circular luminous disc (*i.e.*, one radiating according to the cosine law) by a second parallel and coaxial disc. This is obtained from Sumpner's theory of the whitened globe, and also from first principles. The following applications of the theory are made: (1) It is shown that the surface traced out by the edges of coaxial discs which receive equal amounts of flux from a radiating disc is a hyperboloid of revolution about the common axis of the discs. (2) The amount of flux received from a radiating disc by the walls of a cylinder infinitely long in one direction is found. AUTHOR.

850. *The Art of Camouflage.* **W. A. Howells.** (Illum. Eng., London, 13. pp. 6–12; Disc., p. 13, Jan., 1920.)

851. *Maximum Speed of Kinematograph Film.* **H. Krebs.** (Zeits. Instrumentenk. 39. p. 317, Oct., 1919.)—Gives a method for determining the speed simpler than that previously described by Klughardt [see Abs. 1389A (1919)]. J. W. T. W.

852. *Abnormal Rotatory Dispersion.* **G. Bruhat.** (Ann. de Physique, 13. pp. 25–48, Jan.–Feb., 1920.)—The first part of this paper gives a general study of spectropolarimeters, and includes a description of the apparatus used in an investigation of several coloured tartrates, the results of which are given in the second part of the paper. The apparatus used consisted essentially of a large direct-vision prism in front of which was a lens of focal length 148 cm., and behind which was a mirror capable of rotation. The light source employed was placed at the side, the light being reflected by a right-angled prism so as to pass through the lens and direct-vision prism to the mirror, where it was reflected back through prism and lens to a diaphragm near the right-angled prism. The goniometer to which the mirror was attached was calibrated so that wave-lengths could be read directly. Details are given of measurements made on various tartrates, and it is shown that the difference between the rotation maxima on the red side of an absorption band, and the rotation minima on the violet side, is sensibly equal to the ellipticity maxima within the band. All the results are in agreement with Natanson's law for anomalous rotatory dispersion A. W.

853. *Spectral Analysis of Light from Decomposition of Ozone.* **K. Stuchtey.** (Zeits. Wiss. Phot. 19. pp. 161–197, Jan., 1920.)—Examination of the light from an oxygen-nitrogen mixture in a Berthelot ozone tube showed in the visible region the existence of the second positive group of nitrogen, the emission spectrum of a high oxide of nitrogen (probably N_2O_6, denoted by the letter Y), and the emission spectrum of ozone. The emission spectra of Y and of ozone agree with the known absorption spectra. By heating ozone to 400° in an oven specially constructed for the purpose strong luminous effects were obtained. The light

shows in the visible and ultra-violet regions an emission spectrum of ozone which coincides with the known emission and absorption spectra. An ozonised mixture of oxygen and nitrogen heated in the same oven showed besides the ozone spectrum the emission spectrum of nitrogen oxide Y. The bands of the emission and absorption spectra occupied the same spectral position. The mechanism of the light emission is discussed, and it is shown that the nature of the light is independent of the presence of oxidisable substances. A. W.

854. *Arc Spectrum of Iron in Ultra-Violet.* **H. Schumacher.** (Zeits. Wiss. Phot. 19. pp. 149–157, Nov., 1919.)—Tables are given of the wavelengths of about 360 lines in the spectrum of the iron arc. The lines range from λ2372·62 to λ2104·72 I. units. Details are given of the methods of measurement and interpolation. A. W.

855. *A Mechanical Theory of Series Spectra.* **A. Korn.** (Phys. Zeits. 21. pp. 97–100, Feb. 15, 1920.)—This is the author's second paper on the subject, and deals with a mechanical explanation of the alternating law which governs the spectrum theory. In the first communication [see Abs. 370 (1920)] the author has shown that a mass system $m_0 m$ can give rise to an oscillation series corresponding to the Kayser-Runge formula if a central force $f(r)$ (considered positive when repulsive) acts from m_0 to m, and obeys the following expressions:—

$$
\begin{aligned}
f(r) &= \mathrm{F}'(r),\\
\mathrm{F}(r) &= (\alpha = \beta/r^2)\cos 2\pi r/\lambda + 2\pi v/3\lambda r^3 \,.\, \sin 2\pi r/\lambda,
\end{aligned}
$$

Here α, β, v, and λ are constants.

In the present paper a mechanical explanation is proposed for this system. H. H. Ho.

856. *Regularities of the Second Kind in Line Spectra.* **J. E. Paulson.** (Zeits. Wiss. Photochem. 18. pp. 202–208, Jan., 1919.)—The regularities of the second kind of Kayser concern the constant differences between the wave-numbers observed in spectra in which so far no series have been discovered. The regularities might extend to all lines if they were all measurable. The paper discusses in particular the Zeeman-effect in the spectra of yttrium, palladium, and nickel; the magnetic resolution of the lines of wave-number systems does not concord with the simple rules holding for the series lines, but the author does not doubt that simple relations will be found. H. B.

857. *Short-Wave Measurements in the Cerium Arc Spectrum.* **P. Klein.** (Zeits. Wiss. Photochem. 18. pp. 45–83, Sept., 1918.)—Mainly a tabular account of measurements made in the second order spectrum of cerium nitrate between 2518·509 and 4546·066$\mu\mu$, with the aid of the Rowland concave grating of about 6·5 m. diameter and 20,000 lines to the inch, at Bonn, under Kayser. The results, accurate possibly within 0·003 Å., are expressed in international normals and compared with the previous work of Bakowski and of Exner and Haschek. Intensities are estimated on a scale 1 to 10. The salt is put in a deep hole drilled into the lower, positive carbon; to obtain the iron lines simultaneously with the Ce lines the powdered cerium nitrate is mixed with iron salt. H. B.

858. *Arc Spectrum of Zirconium.* **W. Vahle.** (Zeits. Wiss. Photochem. 18. pp. 84–137, Sept., 1918.)—The work was also done [see Klein, preceding Abs.] at Bonn with the same grating, and Schleussner plates, the zirconium nitrate being placed in a carbon tube of 10 mm. external diameter having a bore of 5 mm. It was found, however, that mixing the salt to be investigated with iron in order to obtain simultaneous spectra is not always reliable; in the case of iron and tin, for instance, the tin evaporates first, and the apparatus might be displaced in the interval before the iron lines become distinct. The range investigated extends from 2285·229 $\mu\mu$ to 7169·044 $\mu\mu$; for long waves the first order spectrum was measured, for wave-lengths below 5658 $\mu\mu$ the second order. The comparison with Bachem's data shows marked discrepancies, due possibly to variations in intensity, pressure, and arc length, which the author discusses. H. B.

859. *The Bohr Theory and the Approximate Harmonics in the Infra-Red Spectra of Diatomic Gases.* **E. C. Kemble.** (Phys. Rev. 15. pp. 95–109, Feb., 1920.)—*Infra-red spectra of diatomic gases; a quantum theory.*—The author's earlier theoretical *explanation of the occurrence of approximate harmonics* in the infra-red spectra of HCl, HBr and CO., based on the non-linearity of the law of force governing the relative displacement of the component atoms, encountered three difficulties: it did nor explain the inexactness of the harmonics; it gave a wrong ratio for the asymmetry constants of the fundamental and harmonic bands; and it was in serious conflict with Kirchhoff's law. It is now shown that by *adopting Bohr's hypotheses* that the molecules possess a series of discrete, non-radiating states of vibration and that the frequencies radiated and absorbed are determined by the energy emitted or absorbed, a new explanation is obtained which seems to overcome the difficulties mentioned above. In connection with the discussion the author presents a full account of his *theory of the asymmetry* of the bands, which postulates a decrease in the frequency of vibration of a rotating diatomic molecule with increasing angular velocity, a consequence of the non-linearity of the law of force. It is found that the theory gives the observed value of the ratio of the asymmetry constants only if it is assumed that the minimum kinetic energy for vibratory motion is not finite as for rotary motion in the Bohr theory, but is zero.

Kirchhoff's law; suggested limitation.—The author's theory of the structure of these band spectra is based on a theory which involves a minor contradiction to Kirchhoff's law, since it leads to the conclusion that the ratio of the intensities of any two component parts of an absorption band is independent of the temperature. This suggests that Kirchhoff's law may not hold in such cases. AUTHOR.

860. *Light Absorption of Unsaturated Compounds in the Ultra-Violet.* **H. Ley.** (Zeits. Wiss. Photochem. 18. pp. 177–191, Jan., 1919.)—A continuation of the work on fluorescence and chemical constitution [see Abs. 488 (1911)], with special regard to the anomalous hypochromous effects of the alkyles in the case of derivatives of styrene, stilbene, and cinnamic acid. When alkyles are introduced into α-compounds one absorption band of styrene vanishes, the other is displaced towards the ultra-violet, contrary to expectation; in β-compounds the displacement is in the opposite direction. The absorption is determined by the method of Hartley-Baly with the aid of iron arcs and alcoholic solutions, and the effects observed are explained after Stark. The alkyle produces a flattening of the field of force quite different from the general effect of the introduction of alkyles into cyclic hydrocarbons; there are, however, exceptional cases. H. B.

861. *Line Spectra of Cadmium and Zinc in the Electrodeless Ring Discharge.* **A. Hagenbach** and **H. Schumacher.** (Zeits. Wiss. Phot. 19. pp. 129–142, Nov., 1919.)—This paper gives numerous tables of lines in the spectra of cadmium and zinc observed in the electrodeless ring discharge. 41 Cd lines and 51 Zn lines given have not been previously observed in the ring discharge. The results show that, generally speaking, the ring discharge spectrum is more like that of the spark than the arc, but that it contains more lines than the arc and spark together. The intensities in the ring discharge spectrum are in some cases totally different from those in the arc and spark spectra. A. W.

862. *Zinc Band Spectrum in the Electrodeless Ring Discharge.* **A. Hagenbach** and **H. Schumacher.** (Zeits. Wiss. Phot. 19. pp. 142–148, Nov., 1919.)—Wave-length tables are presented of the zinc band lines, observed in the ring discharge, with details relative to the character of the lines and their intensity. The results of Howson, Hartley and Ramage, and Morse are included for comparison. Many of the lines have not previously been observed. A. W.

863. *Series in the Spectrum of Argon.* **K. A. Nissen.** (Phys. Zeits. 21. pp. 25–28, Jan. 15, 1920.)—This paper deals with series of multiple lines in the spectrum of argon. Tables are given showing how the lines are arranged, and formulæ of the Ritz type are used to calculate the oscillation frequencies for the lines of the first and second subordinate series of multiple lines and for combination series. The chief interest of the paper lies in the numerical data given. [See Abs. 223 (1920).] A. W.

864. *Absorption Spectra.* **A. S. King.** (Nat. Acad. Sci., Proc. 6. pp. 63–65, Feb., 1920.)—Describes a study of absorption spectra with the tube resistance furnace. The continuous background was supplied by a plug of graphite placed in the centre of the tube, the heated portion of which was 20 cm. long and 12·5 mm. in internal diameter. A close approach to black-body conditions is thus obtained, and the emission of the plugged tube is stronger than that of the metallic vapour filling the tube. An absorption spectrum results, which by simply removing the plug may be compared with the emission spectrum given by the vapour at the same temperature. It is known that in a given range of spectrum some lines are more subject to reversal than others. The present experiments have shown this to result from a close connection between the tendency of a line to reverse and the two factors which enter into the classification of lines in furnace spectra, viz., the temperature at which a line is first radiated, and its response to increase of temperature. When a temperature is reached sufficiently high to produce an absorption spectrum, the lines appearing are those of low-temperature class. As the temperature is raised, lines of successively higher class appear. At a given temperature the absorption spectrum shows fewer lines than are given by the emission spectrum at the same temperature. For the iron and titanium spectra, the absorption spectrum is very similar to that given in emission at a temperature about 400 deg. lower. A. W.

865. *Effect of a Magnetic Field on Electric Furnace Spectra.* **A. S. King.** (Nat. Acad. Sci., Proc. 6. pp. 65–66, Feb., 1920.)—A simple tube furnace was arranged for use in a magnetic field. A graphite tube, 10 cm. long, was placed axially between the poles of a Weiss electromagnet. The jacket enclosing the tube and the contact blocks at the ends were water-cooled. A field of 6500 gauss separated the components of most lines sufficiently to permit measurements of fair accuracy and to show the characteristic features of the source. The spectra of *iron* and *vanadium* received the chief attention. A comparison of lines common to furnace and spark showed no difference either in the number and arrangement of components, or in their separation in the two sources. Separations were obtained for many characteristic furnace lines which the spark emits very faintly. An outstanding feature of these lines for the iron spectrum is a prevailing large separation and simple triplet structure. Lines of this class are often of special interest in the study of sun-spot spectra. With a graphite plug inserted in the tube [see preceding Abs.] the inverse Zeeman-effect can be studied. In this way an extended study was made of the magnetic components in absorption. No difference was observed as to character or magnitude of separation as compared with the effects for the emission spectrum. A. W.

866. *Vibrational Frequencies of the Halogen Acid Molecules.* **W. F. Colby.** (Phys. Rev. 15. pp. 140–141, Feb., 1920. Abstract of paper read before the Am. Phys. Soc., Nov., 1919.)—Imes has shown [Abs. 222 (1920)] that the absorption bands of three halogen acids in the near infra-red can be closely represented by the formula $\nu = \nu_{00} \pm \nu_r n - an^2$, where n denotes successive integers. In accordance with the Bjerrum postulate which ascribes these absorptions to a combination of rotation and inter-atomic vibration of the molecule, the present paper gives an investigation of a molecular model with the object of testing the above formula. The simplest model of the generally accepted type is slightly idealised into four equal electronic point-charges. The two positive charges are associated with the masses of the H and Cl atoms respectively, and held at a definite distance by the two negative charges (electrons) which are revolving in a circular orbit about the atomic axis half way between the nuclei. For such a system it is shown that an approximate solution for x (half the distance apart of the nuclei) is $x = 2 \cdot 917 \times 10^{-9} + 1 \cdot 23 \times 10^{-12} n^2$. From the observed values of ν it is possible to calculate x, and when this is done comparison with the above expression shows that both constants are of the right order of magnitude and represent the observed values closely. Solving similarly for the vibrational frequency the result is obtained: $\nu_0 = 1 \cdot 4485 \times 10^{14} - 4 \cdot 63 \times 10^{10} n^2$, which again agrees well with Imes' formula $\nu_0 = \nu_{00} - an^2$. The above model gives results which agree numerically more closely with the experimental data of low atomic number, which one might expect the point-charge model to represent more accurately. The greater deviations for high number are doubtless due to the screening effect of the inner electrons about the atomic nucleus, which has not been taken into account in obtaining the results given. A. W.

867. *Radiation and Ionisation in Helium.* **K. T. Compton.** (Phys. Rev. 15. pp. 131–132, Feb., 1920. Abstract of paper read before the Am. Phys. Soc., Nov., 1919.)—A simple and convenient device for distinguishing between ionisation and radiation in a gas, and for determining the proportion of the effect due to each when both are present, is used to examine the effect produced in helium when the atoms are bombarded by electrons which have fallen through 20 volts. Theories of radiation and atomic structure lead to the expectation of radiation alone at this voltage, and this prediction is confirmed by recent work of Horton and Miss Davies [Abs. 100 (1920)]. On the other hand, Franck and Hertz have pointed out that some of their results with helium can only be explained by supposing that true ionisation occurs at 20 volts. Preliminary tests have indicated that only ionisation is detected if the gas pressure in the apparatus is relatively high, but that radiation is detected in larger and larger proportion as the gas pressure is reduced. Experiments are not yet decisive on the question as to whether the effect approaches one of pure radiation as the gas pressure approaches zero. The results strongly suggest, however, that the primary effect is radiation, as predicted by theory, and that the ionisation is a secondary effect due to the impact of an electron against an atom which at the instant contains energy absorbed from the radiation by neighbouring atoms. Tests of this hypothesis are in progress. A. W.

868. *Colour Antagonism, or the Chemical and Electrical Polarity of the Spectrum.* **G. Rabel.** (Zeits. Wiss. Phot. 19. pp. 69–128, Oct., 1919.) —The present investigation was undertaken to explore a botanical theory of the physiologist Engelmann that at great ocean depths, no longer penetrable by red rays but only by blue or green, the life of green algæ was impossible, the colours being brown and red—or stated in other words: light absorption and assimilation in general go together. The work of Gaidukow is described on the action of coloured light upon living plants containing chromophyllic substances, whereby complementary colour transformation was observed, for the explanation of which optical resonance was invoked. The present author on repeating Gaidukow's experiment obtained an exactly opposite result, the colour change being direct and not complementary. He has also found that the rays in the red half of the spectrum exert not only other functions to those of the blue, but even opposed effects, *e.g.*, the red light may destroy that which the blue has produced. The author designates such phenomena by the term "colour antagonism." He terms the ultra-red, red, and orange rays positive, and from 450 into the ultra-violet negative light. All bodies are, in the normal state, attuned to positive light so that negative disturbs and positive light causes return to normality. If the substances are kept previous to the experiment in negative daylight, then the positive light will excite change. In the middle of the spectrum lies a region which has the remarkable property, according to circumstances, of acting as positive at one time and as negative at another. Such a property is analogous to that of amphoteric substances in chemistry. The paper is divided into two main parts. Part I, which is subdivided into seven sections, deals with examples of colour antagonism: (1) Phosphorescence, which is found to be excited by negative and extinguished by positive light. (2) Phototropy. Here phosphorus and certain classes of organic substances experience a change of colour in negative light, which change

is reversed in positive light. (3) The photographic plate. Silver salts are reduced by negative, and oxidised by positive rays. (4) Diverse biological and chemical reactions take place in negative light which are reversed in positive. (5) The Becquerel effect. Photo-sensitive electrodes experience in negative light the opposite potential change to that in positive. (6) In this section the retina of the eye is found to belong to these photo-sensitive electrodes. (7) Phototropy in animals and plants. The dynamic reactions of certain of the lower animals and plants are found to be oppositely influenced by positive and negative light.

Part II deals with the space charges in the positively arranged galvanic pile. In such a pile complexes of charges of opposite sign alternate. The potential gradient in the layers is given by the superposition of two independent components, namely, the field potential and the charge potential. A method is now described for effecting the separation of these components, the ordinary process of determining the sign of the free electricity at a point from that of the second differential quotient being found inadmissible. On the other hand the reduction of sodium chloride by negative charges can be utilised to detect these charges in the layers. Full details are given of the experiments made, which are supplemented in an appendix. The conclusions drawn from the experiments are:—Red hydrogen layers exhibit an opposite potential gradient to that of blue steam layers. With the red layer system the potential maximum lies in the luminous layer, the minimum in the dark space between the layers. With the blue layer system the maximum lies in the dark space, the minimum in the layer. With a blue-red double layer the dark space exhibits neither a minimum nor a maximum, but is positive towards the blue border and negative towards the red.

Numerous curves and diagrams are given in the paper. H. H. Ho.

869. *Secondary Spectrum of Hydrogen.* **J. W. Nicholson.** (Nature, 105. pp. 166–167, April 8, 1920.)—The author has made an exhaustive study of the photographs obtained by Merton under various conditions [see Abs. 371 (1920)], and has arrived at the following conclusions. The secondary spectrum of hydrogen consists of a set of band spectra—how far divided into sets which are mutually independent is uncertain, but at least partially so divided—together with a superposed spectrum of single lines. The band lines are those which show no Zeeman-effect, and the lines of the superposed spectrum all show the Zeeman-effect. This general statement still requires a considerable amount of experimental work to establish its complete truth, but the evidence so far available is sufficient to leave little doubt in the matter. Merton's spectra, taken in the presence of helium, preserve the superposed spectrum without much change in intensity, and it is undoubtedly due to a different atomic or molecular mechanism from that producing the bands. This superposed spectrum exhibits very pronounced "constant frequency difference" effects, and there is good reason to believe that sets of series spectra of the ordinary Rydberg type may be included in it and form the basis of the constant differences of wave-number. The series spectra of hydrogen would then no longer be confined to the Balmer series.

On the photographs the behaviour of the "band" lines is peculiar. The "head," a word not used in the ordinary sense, but as denoting the strongest line of the band and the one most remote from the red end, is preserved in intensity in helium, or even enhanced, while all the other members disappear. A line in pure hydrogen may be weak, but if it is really a band-head in this sense, it is prominent in the presence of helium. The head is not always the strongest line in a band in pure hydrogen. This consideration is the real clue to the interpretation of the photographs, and it has been found possible to isolate the entire Fulcher band, which is of a remarkable structure and accounts for the great majority of lines between H_α and H_β, in part of which region the previous measures have been very incomplete and misleading. Other strong bands of similar character occur in other regions, and it is already clear that the complete analysis involves only a few such individual bands showing no Zeeman-effect, together with a line spectrum showing Zeeman-effect, and apparently capable of arrangement in constant frequency-differences. A full account of the investigations will be published later. A. W.

870. *The Fine Structure of the Near Infra-Red Absorption Bands of the Gases HCl, HBr, and HF.* **H. M. Randall** and **E. S. Imes.** (Phys. Rev. 15. pp. 152–155, Feb., 1920. Abstract of paper read before the Am. Phys. Soc., Nov., 1919.)—The doublets which seemed characteristic of the near infra-red absorption spectra of a number of gases were supposedly explained by the combination principle of Rayleigh, viz., that an oscillator which emits and absorbs at a frequency ν_0 in the near infra-red due to its oscillations alone would, when rotating about an axis perpendicular to its line of vibration with a frequency ν_r corresponding to the far infra-red, emit and absorb at the additional frequencies $\nu_0 + \nu_r$ and $\nu_0 - \nu_r$. With a Maxwellian distribution of rotational velocities, the near infra-red band should consist of two broad absorption areas with maxima at $\nu_0 \pm \bar{\nu}_r$, where $\bar{\nu}_r$ is the most probable rotational frequency. With higher resolution the two broad absorption regions have been partially resolved into a number of narrow components whose explanation by the Rayleigh combination principle would require a number of distinct rotational frequencies. The quantum hypothesis would ascribe these to a series of stationary rotational states, in the far infra-red. The partial resolution of these bands, which has been accomplished by the use of prism spectrometers, lacks both the necessary accuracy and completeness to justify the extended theoretical treatment necessary to test either the quantum ideas involved or to construct molecular models. Greatly increased resolution and accuracy have been obtained by using gratings in place of prisms as the dispersing agents. By focusing upon the slit of an infra-red grating spectrometer the spectrum produced by a prism spectrometer, using a salt prism of small refracting angle, the spectral region to be analysed by the grating is too short for the overlapping of spectra, and it is possible to employ the full resolving power of a series of graded gratings, with the result that in several instances the absorption curves show apparently complete resolution. The results are also more accurate, it being possible to determine the position of the narrow absorption bands with an accuracy of a few Ångström units. A curve is given for the HCl band at 3·46 μ when the grating employed had 7500 lines per inch, and the width of the spectrum falling upon the thermopile slit corresponded to 29 Å.U. Each member of the earlier broad doublet is shown resolved into 12 narrow bands. The pairs $\nu_0 \pm \nu_{n,r}$ according to the Rayleigh principle, should be symmetrically grouped about the central position, but the curve shows an unsymmetrical grouping. If the said position of each pair represents the vibrational frequency, it is evident that,

counting from the centre of the band, the successive pairs have their centres located successively farther and farther toward the long-wave end of the spectrum. This indicates that the vibrational frequency is a function of the rotational frequency and that the vibrational frequency is slowed down as the energy stored by rotation increases. If $\nu_{n,r}$ is the distance in terms of frequency of the individual band of each pair from their respective centres, then the relation $\nu_{n,r} = nh/4\pi^2 I$ requires that $\nu_{n,r}/n$ is constant. The experimental results show in all three gases a slight diminution of this quantity. This is most readily accounted for by assuming that I, the moment of inertia of the molecule, increases with the speed of rotation. According to Kemble, there should be a harmonic accompanying the band at $3 \cdot 7\,\mu$ whose wave-length should be exactly one-half that of the fundamental, but on using a grating having 20,000 lines per inch the absorption curve showed the same general departures from symmetry that the fundamentals do and did not substantiate the harmonic relationship. The form of the curve indicated incomplete resolution even with the dispersion furnished by the 20,000-line grating.
H. H. Ho.

871. *Stark-Effect for Argon and Oxygen.* **E. Böttcher** and **F. Tuczek.** (Ann. d. Physik, 61. 1. pp. 107–112, Jan. 8, 1920.)—For argon the same tube was used as had previously been used by Stark, Hardtke, and Liebert [Abs. 1251 (1918)], and a tube of similar glass was employed for oxygen. Direct current was employed, the discharge potential being about 4400 volts for argon and 3400 volts for oxygen. The field strengths were measured by means of the dispersion of the hydrogen lines, the max. field used being 26,000 volts/cm. Tables are given of (1) Lines in the red and blue argon spectra for which no effect of the electric field was observed; (2) spark lines of oxygen showing no effect; (3) arc lines of oxygen for which effects were observed, with dispersion data. These principally belong to the first subordinate triplet series. (4) New oxygen lines. These have wave-lengths λλ4846, 4743, 4634, 4559. Very accurate wave-lengths could not be obtained as the intensity approaches zero value with decreased field strength. The intensity of the *s*-components was so small that no measurements could be made, but the displacement is about the same as for the *p*-components, for which data are given. The new lines only possess appreciable intensity in the presence of an electric field. They are shifted by an electric field towards the violet, in contrast to the lines of the first subordinate triplet series. The intensity increases with decreased wave-length, and the dispersion has about the same value as for the first subordinate triplet series, and for the nearly sharp second principal and subordinate series of helium. [See Abs. 1046 (1919).]
A. W.

872. *Preliminary Observations of the Zeeman-effect for Electric Furnace Spectra.* **A. S. King.** (Mt. Wilson Observat. Contrib., No. 180. Astrophys. J. 51. pp. 107–120, March, 1920.)—*Zeeman-effect for furnace spectra of iron and vanadium.*—Hitherto Zeeman-effect observations have been almost exclusively confined to spark spectra. Because the electric furnace emits or absorbs strongly many lines which are weak or absent in spark spectra, and because it is desirable to compare the effects of a magnetic field on spectra from different sources, the present investigation was undertaken. The furnace tube was placed parallel to the lines of force, in a field varying from 6500 gauss in the centre to 9000 gauss near the ends, and it was heated to a max. temperature of 2200°. To obtain the inverse effect, a carbon plug was placed so as to supply a continuous high-temperature spectrum as a background. Spectrograms were taken with a concave grating giving a scale of about 1·83 Å. per mm. Table I contains the observed separations for both *the direct and the inverse effects, viewed along the lines of force,* for 100 iron furnace lines together with the corresponding separations obtained with the spark as source. Table II contains similar data for the direct effect for 90 vanadium lines. Twenty of the iron lines and eleven of the vanadium lines had not previously been investigated. It was found that the character and magnitude of the separations for the *n*-components of furnace lines both in emission and in absorption agree closely with those of the corresponding spark lines, reduced to the same field intensity; that is, the effect is independent of the source used. Since these three methods give identical results for each line, they may be used to supplement each other in studying the effect. Among other advantages of the furnace, the non-uniformity of the magnetic field enables the location and temperature of the active centres of absorption or emission for various lines to be determined. Spectrograms are reproduced in the original.

Zeeman-effect for the D-lines of the sodium spectrum.—The author suggests a possible *explanation of a variation* of the effect with the source of light, which was *observed by Woltjer.* AUTHOR.

873. *Broadening of Spectral Lines in the Röntgen Region.* **L. Vegard.** (Phys. Zeits. 21. pp. 6–7, Jan. 1, 1920.)—The broadening of spectral lines in the ordinary spectrum is usually considered as due either to the Doppler-effect or to the Stark-effect. The present paper gives a brief theoretical treatment which shows that the broadening of lines in the Röntgen region may be a consequence of the atomic structure on which the author's theory of Röntgen spectra is based. In the case of lines whose broadening is due to either the Doppler or the Stark-effect we have between certain limits practically a continuous distribution of frequencies following a definite law. In the case now dealt with (Röntgen lines) the line is to be regarded as composed of a definite finite number of lines lying very close together. A. W.

874. *Is the Einstein Radiation Factor "h" a Constant?* **F. Sanford.** (Phys. Rev. 15. pp. 67–72, Jan., 1920.)—*K-series of characteristic X-rays; Theory assuming orbital motion of the radiating electron.*—By combining the equation for orbital motion of an electron about a central positive charge and the Einstein photoelectric equation with the following equation for the nuclear charge, $q = 2e(\mathrm{N} - 3\cdot 6)$, the author gets an equation of the form of Moseley's equation, which gives values of λ for the elements from bromine (35) to cerium (58) which agree closely with the observed wave-lengths of the K-radiation. In this calculation, however, h^3/m is assumed constant. Now since the mass of the electron m varies with the speed, if h is constant the ratio h^3/m is not constant and the measured wave-lengths can no longer be computed from the above equation. *Deduction.*—The author presents this as evidence that the *quantum constant "h" varies with the frequency.*

Relation between the β- and γ-rays of RaB; theory.—Assuming the speed of the β-rays is their orbital speed before emission and that the Einstein photoelectric equation gives the relation between the energy of a β-ray and the frequency of the corresponding γ-radiation, the author computes the wave-lengths of the γ-rays corresponding to the various β-rays of RaB. The values differ according to whether h or h/m is assumed to be constant. The agreement between calculated and observed wave-lengths is not striking in either case, but is better if h/m is constant. *Deduction.*—This suggests that the *quantum constant "h" varies with the frequency.* The author does not discuss the discrepancy between the conclusions derived respectively from X-ray and γ-ray data, though it is obvious that h^2/m and h/m cannot both be constant. AUTHOR.

875. *Chemiluminescence.* **I. Lifschitz.** (Helv. Chem. Acta, 1. pp. 472–474, Dec. 1, 1918.)—Chemiluminescence is of quite frequent occurrence, and is not by any means confined to oxidation processes, though very rare in rapid ionic reactions. In organo-magnesium compounds of the type RMgX, which are very convenient for the study, the phenomenon was, according to Moeller, to be limited to aromatic bodies. The author finds that the difference between the aromatic and aliphatic compounds depends upon the relative stability of the etherates. NO_2 acts on phenylmagnesium bromide, *e.g.*, as energetically as air, but does not give rise to a luminescence, which air calls forth provided moisture be absent; in all ether-free Grignard reagents oxygen and nitrous oxide cause luminescence, but not other nitrogen oxides, water and CO_2. On the gradual addition of ether to suspensions of Grignard's reagent in benzene the heat evolution takes place quickly in the case of aliphatic compounds, more slowly (*i.e.* more ether molecules are required) in the case of aromatic compounds. The paper is preliminary and mainly of chemical interest. H. B.

876. *Method for Measurement of X-Ray Intensities; Application to Cu and Al.* **M. Siegbahn and K. A. Wingårdh.** (Phys. Zeits. 21. pp. 83–88, Feb. 15, 1920.)—The problem of exact intensity measurement of X-rays has engaged the attention of many investigators, such measurements lying at the root of almost all X-ray research. Thus it is of importance that exact methods of intensity measurement should be employed in determining (*a*) the coefficients of absorption of chemical substances, (*b*) the reflecting powers of crystals, (*c*) the intensity distribution in line- and continuous X-ray spectra, etc. The authors now describe a "null" method which they claim to be extremely accurate. Two "monochromatic" beams from the same X-ray tube enter two different ionisation vessels, which are connected in relation to the same electrometer. The authors have applied the method to a detailed investigation of the absorption of X-rays of different wave-lengths by Cu and Al, tabulated values of the absorption coefficients being given in the paper. A. B. W.

877. *X-ray Absorption Bands (K-Series) for the Rare Earths.* **M. de Broglie.** (Comptes Rendus, 170. p. 725, March 22, 1920.)—Using a method giving large dispersion, the author has obtained sharp absorption bands whose wave-lengths could be accurately measured. The following results are given:—

The K-band of thulium (N = 69) at $\lambda = 0{\cdot}208 \times 10^{-8}$ cm.
The K-band of neo-ytterbium (N = 70) at $\lambda = 0{\cdot}2015 \times 10^{-8}$ cm.
The K-band of lutecium (N = 71) at $\lambda = 0{\cdot}195 \times 10^{-8}$ cm.

The spectrum of the preparation of thulium, which contained some neo-ytterbium, showed very clearly the simultaneous existence of two elements. A. B. W.

878. *The Calculation of the Intensity of X-rays diffracted by Crystals.* **G. Friedel.** (Comptes Rendus, 169. pp. 1147–1150, Dec. 15, 1919.)—In the expression found for the intensity of a beam of X-rays diffracted by a crystal, the intensity is found to be proportional to $1/\sin^2\theta$, where θ is the angle which the incident beam makes with the diffracting plane. This agrees with the empirical law found experimentally by W. H. Bragg. E. A. O.

RADIO-ACTIVITY.

879. *Thorium-Lead.* **K. Fajans, F. Richter, and [Miss] J. Rauchenberger.** (Akad. Wiss. Heidelberg, Ber. 28 pp. June 8, 1918. Chem. Zentrbl. ii. pp. 438–439, 1918.)—In addition to ordinary lead there should be radium G or radium-lead (the final product of the uranium-radium series) atomic weight 206·94, and further thorium-lead, Th D, about 208·08. To find the latter, minerals free of uranium should be taken. The thorite chosen contained about 30% of Th, and less than 0·5% of U and of Pb. The atomic weight of the Th-Pb isolated was finally determined by Hönigschmid and found to be 207·90. The value is a little too small, which may be due either to the presence of ordinary lead (at. wt. 207·2) or to an instability of Th-Pb which would have a half-period of 1·7 × 10^8 years. In any case the existence of a lead of an atomic weight closely approaching 208·0 is established. H. B.

880. *Effect of Passage of an α-Ray Through an Atom.* **R. A. Millikan, V. H. Gottschalk and M. J. Kelly.** (Nat. Acad. Sci., Proc. 5. pp. 591–592, Dec., 1919.)—Millikan (Phil. Mag. 21, 1911) has shown by the falling oil-drop method that the act of ionisation by X-, β- or γ-rays uniformly consists in the detachment of a single negative electron from a neutral atom. More recently Millikan attacked the more difficult problem of determining by the same oil-drop method the number of ions formed when an α-particle passes through an atom, expecting to find that this relatively huge and powerful ionising agent would often detach more than one negative electron from a single atom. The experimental work has been continued and completed by Gottschalk and Kelly. The results are as follows:—(1) Alpha rays have been shot through atoms of H, C, O, N, Cl, I, Hg without bringing to light in any case evidence of formation of multi-valent ions. (2) Twenty-nine hundred ions formed by the passage of α-rays through neutral molecules have been caught on oil drops at the instant of ionisation and the charges carried by these ions individually measured. Of these 2900 captures, 5 might possibly have corresponded to double charges, though even these were in all probability due to the nearly simultaneous advent upon the drop of two singly-charged ions. (3) In no single case has an α-particle been observed to form an ion carrying 2 or more charges, even though mercury, from which octivalent ions had been expected, was one of the substances tested. (4) Alpha-ray ionisation consists, then, at least 99 times out of 100, in the case of all the gases and vapours studied, in the detachment of a single negative electron from a neutral molecule. A. B. W.

881. *Nature of the Process of Ionisation of Gases by α-Rays.* **R. A. Millikan, V. H. Gottschalk** and **M. J. Kelly.** (Phys. Rev. 15. pp. 157–177, March, 1920.)—*Ionisation of gases by α-rays; valency of the ions.*—By catching an ionised molecule upon an oil drop at the instant of ionisation and then measuring the charge thus added to the drop, it has been directly proved that the ionisation of an air molecule by either β-, γ-, or X-rays uniformly consists in the detachment of one electron. In the case of ionisation by α-rays, the authors show by an extended discussion of previous work bearing on the subject that while some experiments indicate the possibility of the formation of multivalent ions, none of them is conclusive. Therefore, the droplet method was used to supply direct evidence. The necessary modifications of apparatus are described and the experimental procedure. Uncovered radium furnished the α-rays. The gases tested were *air, carbon dioxide, carbon tetrachloride, methyl iodide*, and *mercury dimethyl*; so that α-rays were shot through atoms of H, C, O, N, Cl, I, and Hg, which vary in atomic weight from 1 to 200. *Experimental results.*—Altogether 2900 ions were each caught on an oil drop at the instant of ionisation, and each had its charge determined. Of these captures, only 5 corresponded to a double charge and no ion was caught which carried three or more elementary charges. How many of the 5 double charges obtained were due to doubly-charged ions and how many to simultaneous catches of two singly charged ions, is unknown. In any case the results prove that, at least 99 times out of 100, ionisation by an α-ray, in the case of each of the gases and vapours studied, consists in the detachment of a single electron from a molecule. The observations for 170 captures by three droplets in three gases are given in detail. The paper ends with a *discussion* of the circumstances under which multivalent ions may possibly be produced by α-rays. AUTHORS.

882. *Crystal Structure and α-Rays.* **K. Heil.** (Ann. d. Physik, 61. 2. pp. 201–220, Jan. 15, 1920. Dissertation, Freiburg.)—The author examines the influence of crystal structure on the range and scattering of α-particles. Thin crystal plates of mica and gypsum were employed in the investigation. With regard to the range of the α-particles it was demonstrated by both photographic and ionisation methods that "resistance to penetration" is least in the direction of the elastic axes of the crystals. A similar polarisation effect has been shown to exist also in regard to the scattering of the α-particles. These effects are, however, only very small. A. B. W.

883. *Radio-active products in the Free Atmosphere.* **H. Bongards.** (Phys. Zeits. 21. pp. 141–145, March 15, 1920.)—An investigation is described on the radio-active decay-products in the free atmosphere. The activity of a charged wire has been measured at a height of 1500 m., and also the relation between activity, air-pressure on the ground, and the temperature in the layer between 1000 m. and 2500 m. In the temperature range of the stratosphere there appears to be an undoubted connection between temperature and activity. The possibility is suggested, on the basis of the results obtained, that at any rate a portion of the radio-active matter collected may have its origin in the sun. A. B. W.

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HEAT.

884. *A New Method of Determining the Temperature Variation of the Thermal Conductivity of Gases.* **G. H. Henderson.** (Phys. Rev. 15. pp. 46–57 and 58–66, Jan., 1920.)—*Measurement of gas temperature.—Radiation error if the bounding surfaces are not all at the same temperature.* A *mathematical expression* is derived which enables the radiation error to be determined for a thermo-element consisting of two wires of known diam., if the radiant heat gained per sec. per unit length can be computed. It is based on Langmuir's equation for the heat loss by conduction and free convection. The author applies it to the case of a thermo-element between two parallel plates maintained at different fixed temperatures, and gives a table of corrections to be applied to thermo-elements of various diameters. The assumptions made are such that the probable error of a correction computed in this way may be large. *An alternative method of eliminating the radiation error* is that adopted by Kreisinger and Barkley. It consists in making measurements with a number of thermo-elements of decreasing diameter and in extrapolating from the results to the value which would be obtained with an element of zero diameter. This method is discussed and some *precautions* are suggested. AUTHOR.

885. *Relation between Boiling-Points at One Atmosphere and in a Vacuum* (20 *mm.*). **W. P. Jorissen.** (Zeits. Anorg. Chem. 104. pp. 157–162, Oct. 25, 1918.)—According to Guye-Guldberg and to Herz, the critical temperature of any substance is approximately equal to twice the boiling temperature in a vacuum (at 20 mm.), and also equal to 1·55 times the boiling-point at 1 atmo.; the ratio T_{20}/T_{760} should hence be constant $= \pm 0{\cdot}78$. This holds approximately, it is shown, for many elements and compounds, inorganic and organic, the data being taken from various authorities. The constancy was already deduced by J. van Laar from van der Waals, but it had previously been pointed out by Clausius (after Groshans, 1849) and again by Dühring and by Ramsay and Young. H. B.

886. *The Isentropic Coefficient of Expansion.* **S. Ray.** (Phys. Rev. 15. pp. 24–29, Jan., 1920. Paper read at the Science Congress, Calcutta, March, 1919.)—*Isentropic coefficient of expansion.*—The square root of the ratio of the specific heat to the isopiestic coefficient of expansion of a substance has the dimensions of a velocity. The ratio of this quantity to the velocity of sound in the substance is therefore a pure number which is proved by the author to be equal to $\sqrt{(-\theta a_\phi)}$, where a_ϕ is the isentropic coefficient of expansion. If we call the quantity in brackets h, then *for gases*, $h = 1/(\gamma - 1)$ where γ is the ratio of the specific heats. *For liquids*, k is found to be approximately equal to unity, which means that $a_\phi = -1/\theta$, a law analogous to Charles' law for gases. *For solids*, k varies from about 0·3 to 1. It is seen that as any substance passes from the gaseous through the liquid to the solid state, h decreases from more than 1 to less than 1. The significance of this fact with reference to the theory of corresponding states is briefly discussed.

Thermodynamic equations for the expansion of liquids and solids.—The author shows that the *generalised adiabatic equation for any substance* is $v\theta^h =$ constant, and he derives the following *general expansion law for any substance*, an extension of the general gas law: $pv = ms_p/\theta\beta_v\,(a_p - a_\phi)$, where $\beta = dp/pd\theta$. AUTHOR.

887. *Spectral Distribution of Radiant Energy of Metals.* **G. R. Greenslade.** (Phys. Rev. 15. pp. 150–152, Feb., 1920. Abstract of paper read before the Am. Phys. Soc., Nov., 1919.)—Energy curves for a number of different temperatures were taken for the following metals :—Au, Fe, Ni, Co, Rh, Ir, Mo, W. Each metal was rolled into a thin sheet and then folded so as to form a V of small angle. The temperature was measured by focusing an optical pyrometer into the black-body crevice of the V, while the polished outside surface radiated to the analysing apparatus which consisted of a reflecting spectrometer and a receiving bolometer. It was found that the total radiated energy, as well as the form of the wavelength–energy curve, varied with the purity of the metal. J. W. T. W.

888. *Specific Heat and Equation of State of Crystals.* **K. Försterling.** (Ann. d. Physik, 61. 6. pp. 549–576, March 16, 1920.)—The author has previously derived the law of thermal dilatation of isotropic monatomic bodies from the Hamiltonian principle, while Born has developed the dynamics of the crystal lattice to include mono- and poly-atomic crystals. Thermal dilatation stands in close connection with the energy content of the body in question, and since the theory of Born and Karman is not altogether in consonance with observation, the author has sought to establish by the application of this Born theory to examples whether it should be rejected as proposed by Grüneisen [see Abs. 1105 (1918)]. According to Born, the energy content falls into two parts corresponding to the motion of molecules as entities, and to the atomic motion within the molecules. Born develops the former partly by Debye's method, and the latter according to Einstein's hypothesis. While Debye, however, postulates a common boundary frequency for the transverse and longitudinal waves, Born assumes a special frequency for each wave species. An experimental decision between these assumptions has hitherto not been possible, but the author now establishes on the theory of thermal dilatation that Born's hypothesis is incompatible with the second law of thermodynamics, while that of Debye is in agreement. The first part of the paper deals with the question of specific heat under 4 sections :—(1) The development of general formulæ; (2) regular crystals; (3) trigonal crystal system; (4) an extension of previous hypotheses on the subject. The second part of the paper considers the equation of state of crystals under 3 sections :—(1) The Born-Karman theory of the crystal lattice; (i) results to be derived from the equation of state; (ii) isotropic monatomic bodies. [The paper is mathematical throughout. H. H. Ho.

889. *Absolute Temperature and Corresponding Absolute Pressure of Moist Vapours. Criticism of Raoul Pictet's Equation of State.* **O. Venator.** (Zeits. Phys. Chem. 93. pp. 242–244, and pp. 247–249, Oct. 8, 1918.)—The author questions the consistency of van der Waals' equations, drawing attention to a fuller discussion of the problems, from their technical aspects, given by himself in the Zeits. Gesamt. Kälte-Industrie, Jan. and Feb., 1918. The *a* of van der Waals is not constant, but has minima at the absolute zero and at the critical temperature, increasing to a maximum. The second paper expresses the relationship between the absolute temperature and the absolute pressure of moist vapours by $a = (T_k/T - 1)\ (\log p_k - \log_p)$, where the *k* indicates the critical values in kg/cm.^{2} and T and *p* stand for any temperature.

(*Ibid.*, pp. 245–246, Oct. 8, 1918.)—The author criticises Pictet's equation which is of the form of that of van der Waals; neither of these equations, however, satisfies the demands of technology. The comments refer to the expositions given in Wüllner's *Experimental Physik*. H. B.

890. *Vapour-pressure Regularities.* II. **W. Herz.** (Zeits. Elektrochem. 25. pp. 45–46, Feb. 1, 1919.)—According to Ramsay-Young, the coefficient c in the formula $\theta/\theta_2 = T_1/T_2 + c(\theta_1 - T_1)$, where the θ are the boiling-points of two substances at one pressure and the T the same at another pressure, should be a constant. The author calculates the c from the halogens, also O, N, S, A, Kr, Xe, Cu, Sn, etc., and finds that, always very small, it may approximately be regarded as constant in the case of non-metals, but may be positive or negative in the case of metals, ranging for Pb, *e.g.*, from $-0{\cdot}0003\,k$ to $+0{\cdot}0006$ (about). The author is inclined to question the accuracy of boiling-point determinations. H. B.

891. *The Chemical Constant and Moment of Inertia of the Molecule and the Quantum Theory of Gases.* **L. Schames.** (Phys. Zeits. 21. pp. 39–42, Jan. 15, 1920.)—If the chemical constant is numerically known for the polyatomic gas when the quanta effect, on the one hand, and the internal degrees of freedom on the other, are imperceptible, then the moment of inertia may be calculated. The results so obtained are now compared with those given by other investigators. Following this the characteristic temperature is derived from the chemical constant of rotation from which the quantum decrease of rotation takes place. In analogy with this the chemical constant of translation is connected to its characteristic temperature. The data used in the paper are calculated for the gases O, CO, N, CO_2, and H_2O. H. H. Ho.

892. *Cooling of Gases by Internal and External Work.* **R. Plank.** (Phys. Zeits. 21. pp. 150–156, March 15, 1920.)—The author first deals with reversible and non-reversible processes for bringing about the cooling effect in gases, and then discusses the two forms of liquefaction apparatus by Claude and Linde respectively. The former, working under a reversible adiabatic expansion, has the advantage that the external work done may be evaluated; but the latter, based on the utilisation of the internal irreversible work, becomes a practical proposition at the higher pressures and lower temperatures employed. Section 2 considers the final cooling effect. [The paper is mathematical throughout.] H. H. Ho.

893. *Derivation of the Chemical Constant of Polyatomic Gases from Planck's Theory of Probability.* **L. Schames.** (Phys. Zeits. 21. pp. 38–39, Jan. 15, 1920.)—While the value of the chemical constant is accurately known for the monatomic gas, this knowledge is much less accurate for the case of the polyatomic gas, notwithstanding the work of Tetrode and Sackur. [See Abs. 880 (1913).] The chemical constant of the polyatomic gas is now derived in general form from Planck's theory of probability, and at such a high temperature that the quanta effect is no longer noticeable. The result obtained is compared with that evolved by Sackur and Tetrode, and the divergence discussed. The paper is entirely mathematical. H. H. Ho.

SOUND.

894. *Variably-coupled Vibrations : Gravity-Elastic Combinations.* **L. C. Jackson.** (Phil. Mag. 39. pp. 294–304, March, 1920.)—The present paper describes a continuation of the work of E. H. Barton and H. M. Browning on coupled vibrations [see Abs. 1221 (1917)]. The coupled system here used consists of an inverted elastic lath pendulum and a gravity pendulum, which can be attached to the lath at different points along its length. The degree of coupling of the pendulums thus depends upon the position on the lath of the point of suspension of the gravity pendulum. The mathematical theory of this coupled system is developed and experimentally confirmed. The paper is illustrated by 32 photographic records of the traces obtained for the motion of the gravity bob under various conditions of starting and coupling, the masses and periods being each equal. The system here discussed give very similar results to those previously obtained with the cord and lath pendulum (by the authors referred to) and can be used as an analogy to the electrical case of circuits of equal inductances and frequencies. It is hoped in a later paper to deal with the more general case of the same arrangement in which both masses and periods are different. E. H. B.

895. *Recording and Reproducing Sounds by Means of Light.* **A. O. Rankine.** (Phys. Soc., Proc. 32. pp. 78–82; Disc., 82–83, Feb., 1920.)—The light from the photophone transmitter previously described by the author [Abs. 153 (1920)] is concentrated on a narrow slit, an image of which is produced by means of an auxiliary lens on a strip of kinematograph film, the slit image being transverse to the film. The variations in intensity of the light when sound waves are received by the instrument are recorded as variations in the density of the film after development. For reproduction of the sounds, light from an illuminated slit is focused on the film, behind which a selenium cell, connected to a telephone circuit, is placed. As the film moves, the intensity of the light reaching the cell varies in accordance with the density of the film, and the corresponding sound is heard in the telephone. AUTHOR.

896. *Mechanical Violin-Player for Acoustical Experiments.* **C. V. Raman.** (Phil. Mag. 39. pp. 535–536, May, 1920.)—Describes with photographic reproduction the author's device by the aid of which the following lines of investigation may be studied :—(*a*) Relation between bowing pressure and position of bowed point ; (*b*) relation between speed and pressure of bowing ; (*c*) variation of bowing pressure with pitch, and phenomena of the wolf note ; (*d*) effect of mute on pressure of bowing ; (*e*) quantitative relation between tone-intensity and pitch for different types of instrument. Further details are forthcoming. E. H. B.

897. *Energy of Possible Standard of Sound.* **C. T. Knipp.** (Phys. Rev. 15. pp. 155–156, Feb., 1920. Abstract of paper read before the Am. Phys. Soc., Nov., 1919.)—The new source of sound recently described [see Abs. 323 (1919)] has now been quantitatively tested by a calorimetric method as to the total energy taken and the fraction of it used in sound. In the three tests made the fracture of total energy converted into sound came out at 2·19, 1·90, and 1·80 %. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

898. *Ampère Molecular Currents.* **G. Arvidsson.** (Phys. Zeits. 21. pp. 88–91, Feb. 15, 1920.)—In 1915 A. Einstein and W. J. de Haas published a paper on the Ampère molecular currents in iron [see Abs. 1123 (1915)]. This showed that the phenomena of ferromagnetism could be regarded as due to electrons rotating in iron after the theories of Langevin and H. A. Lorentz. As a consequence of this a couple should act upon a magnet while its magnetisation changes; further, the expression for this couple involves the ratio e/m. The present author here describes experiments undertaken to determine the ratio in question by this method. The values obtained are of about twice the accepted value, namely, $(3 \cdot 35 \text{ to } 4 \cdot 16) \times 10^7$ e.m. units per gm. E. H. B.

899. *An Extension of the Electron Theory of Metals.* II. *Thermoelectric and Conductivity Constants.* **A. E. Caswell.** (Phys. Rev. 15. pp. 1–11, Jan., 1920.)—*Theory of metallic conduction assuming free electrons and positive centres; comparison of computed with experimental results.*—In the preceding theoretical paper [Abs. 420 (1920)] the author has deduced a number of equations for the phenomena of thermo-electricity and metallic conduction. These are in fairly good agreement with the experimental facts within the range of ordinary temperatures, providing proper values are given to the constants for the various metals. To determine whether the values of the constants derived from one phenomenon will agree with those derived from other phenomena, the *constants for the thermo e.m.f., the Peltier e.m.f. and the Thomson e.m.f.* were computed from the experimental results for the thermoelectric power. While good agreement with observed values was found for the first two phenomena, for the Thomson e.m.f. and its temperature gradient the computed results frequently have the wrong sign, though they are of the right order of magnitude. The computed *variation of conductivity with temperature* agrees closely with the experimental results for copper for the range 0–70°, but the departures at higher temperatures are large and suggest that the equation needs modification. *Deduction.—The concentration of free electrons and positive centres* computed from thermoelectric data indicate that the observed differences of electrical conductivity among the various metals depend principally upon differences in the concentration of positive centres. AUTHOR.

900. *Electric Charge on Rain.* **J. A. McClelland** and **A. Gilmour.** (Roy. Irish Acad., Proc. 35. pp. 13–29, April, 1920.)—The experiments, made in Dublin, are spread over the period Jan. to Aug. 1919 inclusive. The apparatus consists in brief of a receiving vessel connected with a Dolezalek electrometer, and discharged automatically when 22 cm.^{3} of water are collected. The main results are:—(1) Rain is never found uncharged. (2) Of non-thunderstorm rain $73 \cdot 5\%$ is found positively charged, 84% of the electricity brought down being positive. Average positive charge per cm.^{3}, $0 \cdot 21$ e.s. unit; average negative charge,

0·08 e.s. unit. Average vertical current due to positive rain, $1 \cdot 6 \times 10^{-15}$ amp. per cm.^{2}; negative, $0 \cdot 5 \times 10^{-15}$ amp. per cm.^{2}. No general relation is found between charge and size of drops, but rain, consisting of drops smaller than $0 \cdot 08 \times 10^{-6}$ cm.^{3}, is always negatively charged. (3) During two thunderstorms examined 54·2% of rain was positively charged, and 50·3% of electricity brought down positive. This rain was more highly charged than ordinary rain. (4) Charge on hail and snow is higher per cm.^{3} than on rain, and often than on thunderstorm rain. Snow is mostly negatively charged, small hailstones always negatively and large hailstones always positively. M. A. G.

901. *Effect of X-Rays on the Charges of a Permanently Polarised Dielectric.* **M. Eguchi.** (Phys. Math. Soc. Japan, Proc. 1. pp. 45–51, March, 1920.)—The author describes an experimental investigation of the temporary destruction of the apparent charges of a permanently polarised dielectric by X-ray exposure, and the recovery of the charges after the withdrawal of the X-rays. A. B. W.

DISCHARGE AND OSCILLATIONS.

902. *Radiation Produced by Partial Ionisation.* **C. D. Child.** (Phys. Rev. 15. pp. 30–37, Jan., 1920.)—*Emission of light by gases; a partial ionisation theory.*—In certain cases light seems to be emitted at the instant of ionisation of the gas atoms; in other cases it seems to be emitted at the instant of recombination of gas ions; and in still other cases the light emission seems to be associated with neither ionisation nor recombination. These cases are discussed and an explanation is suggested which is based on Bohr's assumption that radiation occurs when an electron falls from an outer to an inner orbit, combined with the assumption that complete ionisation is produced much less frequently than partial ionisation, that is, the displacement of an electron from an orbit to one farther out. Partial ionisation would not affect the current or the electric field, so its existence cannot be directly proved, but is rendered probable by the recent demonstration of radiation without ionisation. The readjustment following it may be expected to produce radiation similar to that produced by recombination after complete ionisation. The evidence given by canal rays is briefly discussed. The author's theory apparently explains all the phenomena cited.

Low-voltage discharge in Hg vapour.—If a Wehnelt kathode is used, a low-voltage discharge may be maintained which is relatively nonluminous for some distance from the kathode. AUTHOR.

903. *Disruptive Potential in Carbon Dioxide at High Pressures.* **C. E. Guye and P. Mercier.** (Archives des Sciences, 2. pp. 30–49, Jan.–Feb., and pp. 99–124, March–April, 1920.)—The object of the present work is to reproduce with greater accuracy experiments on the disruptive potential in compressed CO_2, and at the same time investigate if the polarisation of the gas at high densities is not such as will create a molecular field likely to facilitate the passage of the discharge at high pressures. The experimental arrangement has been greatly improved, and the discharge chamber made so as to allow the use of larger electrodes. It is found that at atmospheric pressure, with plane electrodes 45 mm.

in diam. and incurved edges, the disruptive potential for the same distance is greater in air than in CO_2, but this difference seems to disappear at small distances. Ultra-violet rays seem to have more effect in lowering the disruptive potential in CO_2 than in air. This action of ultra-violet light diminishes rapidly as the pressure increases; at 10 atmospheres it is insignificant. For great distances (5, 4, 3, and 2 mm.) the disruptive potential as a function of the pressure increases in a linear manner, the max. pressure attained being about 10 atmos., while for distances of 1 mm., and especially 0·5 mm., the curves bend clearly in proportion as the pressure increases, the latter attaining about 30 atmos. for the smaller distance. The phenomena tend, then, to change, and the shape of the electrodes seem to play an important part in the value of the disruptive potential. Notwithstanding the uncertainty which results from this modification of the discharge an attempt is made to verify the law of Paschen, to represent the results by the curves $V = f(pd)$ and $V = f(\delta d)$. It is found that the former of these relations is more closely verified than the second. Experiments carried out with electrodes of varying shapes lead to the following conclusions:—With homologous fields the explosive potential $V = f(p)$ is represented by curves which differ little from those obtained with plane electrodes, at least for distances 5 mm. and 1 mm.; on the contrary, the divergence is very marked for distance 0·5 mm. When the results obtained with spherical caps are represented by the curves $V = f(pd)$ and $V = f(\delta d)$, those relative to distances 1 mm. and 0·5 mm. more nearly approach the curves relative to greater distances than those obtained with plane electrodes; in other words, Paschen's law is more nearly verified in the case of electrodes shaped as spherical caps than it is with plane electrodes.

Conclusions.—From the results obtained it is concluded that the modifications observed in the discharge, particularly at short distances with plane electrodes, can be accounted for by known causes of error. Under such conditions the spark becomes large and luminous, and it produces a sound which gives the impression of a shock. This, it is suggested, may be explained by the slowness with which the ions are displaced in compressed gas, an accumulation of positive and negative ions taking place in the neighbourhood of the electrodes. This has a double effect: it diminishes the explosive potential, and it increases the energy of each spark. To settle this question definitely it would be necessary to make systematic experiments upon electrodes of different shapes and dimensions at several pressures. A. E. G.

904. *Duration of Light Emission from a Radiating Hydrogen Atom.* **A. J. Dempster.** (Phys. Rev. 15. pp. 138–139, Feb., 1920. Abstract of paper read before the Am. Phys. Soc., Nov., 1919.)—Canal rays were passed through a small hole directly from a discharge tube into a second tube with a much higher vacuum. The object of the experiments was to make the pressure in the second chamber so low that the natural rate of dying out of the fast-moving luminous particles coming in from the discharge tube could be observed. The difference in pressure on the two sides of the hole was maintained by means of a mercury-vapour pump which continually drove the gas from the second tube back into the discharge tube. By starting and stopping the pump the pressure in the second chamber could be changed from that of the discharge tube to a pressure very much lower without altering appreciably the pressure in the discharge tube itself. With the same pressure on both sides of the hole the canal rays gave a luminous bundle extending the whole length of the second chamber. As the pump began to work the upper part of the bundle became fainter, and when the pump was in full operation, the second chamber was perfectly free from general gas luminosity, and the upper part of the canal-ray bundle disappeared completely. The rays issuing from the hole in the kathode were still bright, but died out gradually in a distance that could be readily observed. With a discharge tube about 3 cm. in diam., the bundle extended about 4 cm. beyond the hole. In another tube 2·2 cm. in diam., where the discharge tube pressure was greater and the velocity of the rays less, the bundle died out in 3 to 3·5 cm. The speed of the canal rays may be obtained from Doppler-effect measurements. For conditions similar to those in the first tube, the fastest rays have a speed of approximately 9×10^7 cm. per sec. The time required for the radiating particles to die out is therefore approximately 5×10^{-8} sec. The light observed is practically entirely due to H_β. The value thus obtained agrees in magnitude with an estimate made recently by Stark by a different method. For H_γ he obtained 4×10^{-7} sec., and stated that the time for H_γ, H_β, and H_α is less than this. **A. W.**

905. *New Discharge Tube allowing all its Rays to Emerge.* **W. E. Pauli.** (Phys. Zeits. 21. pp. 11–14, Jan. 1, 1920.)—Acting on the principle of Lenard's "window," the author has two such windows in the axial line of the rays, one from the main discharge tube into an auxiliary chamber, and a second from the auxiliary chamber to the atmosphere. Thus, the pressure in the auxiliary chamber may be about the thousandth of an atmosphere, and that in the main tube a thousandth of that, and consequently the millionth of an atmosphere. Three diagrams and full details are given in the paper. **E. H. B.**

906. *Positive Rays.* **J. J. Thomson.** (Engineering 109. pp. 286–287, Feb. 27; 318–319, March 5; 335–337, March 12; 384–386, March 19; 402–403, March 26, and pp. 453–455, April 2, 1920. Electrician, 84. pp. 319–320, March 19, and pp. 397–398, April 9, 1920. Lectures delivered at the Roy. Inst.)

907. *Hertzian Gratings.* **R. Gans.** (Ann. d. Physik, 61. 5. pp. 447–464, March 3, 1920.)—The treatment is mathematical and includes the cases of electric vector respectively parallel and perpendicular to the grating wires, which are assumed to be infinitely conducting. [See Abs. 1894 (1907).] **E. H. B.**

908. *Shortest Waves obtainable with Valve Generators.* **H. Barkhausen and K. Kurz.** (Phys. Zeits. 21. pp. 1–6, Jan. 1, 1920.)—Taking the case of a valve with central filament and concentric grid and anode, of diameters d_g and d_a respectively, an expression is obtained for the wave-length of the oscillations generated. If E_g and E_a are the potentials of grid and anode respectively, the wave-length is given by $\lambda = (1000/E_g^{1/2}) \,.\, (d_aE_g - d_gE_a)/E_g - E_a)$. With a Schott M-valve measurements were made of the wave-lengths obtained with the grid potential positive (140 to 200 volts) and the anode potential varying from + 4 to − 300 volts. The wave-lengths obtained varied from 240

to 104 cm., and in all cases the calculated wave-length was higher than the observed. The effect of the space charge and the form of the valve used is discussed, and it is concluded that the shortest wave-length obtainable with a Schott K-valve, with anode diam. of 2·1 cm. and 500 volts on the grid, is about 43 cm. With a valve whose anode diam. is 0·5 cm. it should be possible to obtain a wave-length of about 10 cm. Practical applications are discussed. A. W.

909. *Absolute Measurement of Frequency of Electrical Oscillations.* **J. Tykocinski-Tykociner.** (Phil. Mag. 39. pp. 289–294, March, 1920.) —Describes the method devised by Mandelstam for the measurement of radio frequencies. Mandelstam found that oscillations in a circuit energised by a high-toned buzzer do not depend solely on its capacity and inductance, but depend also upon the frequency of the pulsating current delivered by the buzzer, and to a large extent on the character of its interruptions. A buzzer can be made, in connection with another circuit, a source of trains of oscillations possessing a wide scale of frequencies. The amplitudes of the variety of oscillations obtained are not equal for all frequencies, but depend upon the ratio of the frequency of generated oscillations to the number of interruptions per second of the buzzer. Those oscillations, the frequencies of which represent exact multiples of buzzer interruptions, have the largest amplitudes. This fact was utilised in the following way: A buzzer B, giving regular interruptions, excites an aperiodic circuit I, consisting of a resistance R and inductance L. This circuit is coupled to a second circuit II, capable of performing free oscillations, with its variable capacity C_2 and inductance L_2. A circuit III is also coupled to II, and contains either a thermo-element with galvanometer or a detector with a telephone. By varying C_2 a great number of maxima of the oscillating currents in II can be observed, arranged in definite positions all along the scale of C_2. If the buzzer interruptions are decreased the maxima come closer together, and open out if the interruptions are increased. If n be the number of interruptions per sec. of the buzzer, ν_1 the natural frequency to be measured of the circuit II with a certain position of the condenser C_2'', ν_2, a higher frequency of the circuit II with another position of the condenser C_2'', s the number of maxima observed while varying the condenser from C_2' to C_2'', then $\nu_1 = s \, . \, n/(\nu_2/\nu_1 - 1)$. n can be measured by any acoustical or optical method. The best way of finding the ratio ν_2/ν_1 is to choose C_2'', so that the natural frequency of circuit II for that position shall be a known multiple of that to be measured (C_2'). This can be done by excitation of circuit II from a separate source energised by an arc or valve transmitting circuit. Details are given of the actual method employed for calibrating wave-meters. A. W.

910. *Damped Oscillations in Coupled Circuits.* **G. B. Ehrenborg.** (Radio Rev. 1. pp. 220–224, Feb.; 329–336, April, and pp. 375–380, May, 1920.)—In the mathematical treatment of the phenomena in two coupled circuits the starting-point is a system of two linear differential equations of the second order. Each of these belongs to one circuit, in the sense that the majority of the terms in it refer to the voltage (or current) in that circuit; but there are also terms, called for convenience cross terms, which are derived from the voltage in the other circuit. Owing to the presence of these cross terms, the problem depends on the solution of a biquadratic, and hence it seems worth while to try to effect such a change of variables that in the transformed system of differential equations the cross terms are as small as possible; if the damping is small, one would naturally try to arrange matters so that only the cross terms are damping terms. The object of the present paper is to apply this method to the study of the free oscillations in two circuits electromagnetically coupled, that transformation being chosen which is most nearly in accord with practical conditions. It is found that the biquadratic can then in general be broken up into two quadratic factors without any serious error. If a certain relation holds between the resistances and capacities, the error vanishes, so that the solution obtained is exact. Further, an estimate can be easily made of the magnitude of the error when this relation ($R_1C_1 = R_2C_2$) no longer holds; and the evaluation of the integration constants is a far less laborious process than would have been the case if no change of variables had been carried out. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

911. *Spectro-Photoelectric Sensitivity of Thalofide.* **W. W. Coblentz.** (Phys. Rev. 15. pp. 139–140, Feb., 1920. Abstract of paper read before the Am. Phys. Soc., Nov., 1919.)—Continuing the investigation of the spectro-photoelectric sensitivity of various substances [see Abs. 427 (1920)], the author has examined thalofide, a laboratory preparation discovered by T. W. Case. This substance has a complex band of high photoelectric sensitivity, with maxima in the region of 0·9 μ and 1 μ. At room temperature it appears to be insensitive to radiation of wavelength greater than 1·3 μ. The photoelectric response attains its maximum very quickly, and unlike the selenium cell, there is no great lag in recovery after exposure to light. In view of its high sensitivity, an attempt should be made to use this device in measuring variable stars, etc. Used in connection with the potassium-hydride photoelectric cell, which is sensitive to the violet, valuable information should result from simultaneous measurements with the two. A. W.

912. *Unipolar Conductivity of Crystals.* **F. Streintz** and **A. Wesely.** (Phys. Zeits. 21. pp. 42–50, Jan. 15, 1920.)—The measured resistance of a crystal is the sum of two quantities. The first of these is the resistance σ of the crystal itself, and the second the contact resistance w [see Abs. 1724 (1911)]. The self-resistance follows Ohm's law, and depends on temperature in the same way as the resistance of metals. The contact resistance does not follow Ohm's law, and the dependence on temperature follows an exponential law, $w_t = w_0 e^{-at}$. The contact resistance is also affected by the current strength and by the pressure applied to the conductors in contact with the crystal. Experiments were carried out with cylinders of lead glance and arsenical pyrites. Denoting the ends of the cylinder by the numbers 1, 2, it was found that the current i_{12} differed from i_{21}. For lead glance, with gradually increased current strength, it was found that a linear relation existed between i_{12} and i_{21}/i_{12}. Defining the unipolarity U as the ratio $(i_{12} - i_{21})/i_{21}$, the experiments showed that U was approximately inversely proportional to the potential applied between the opposite faces. The unipolar conductivity is connected with a temperature difference between the opposite faces of the crystal. The weaker current flows through the crystal from the warmer to the cooler contact face. The temperature difference between the contact faces depends on the direction of the current. With increased current strength the contact resistance decreases, while the unipolarity increases. Both contact resistance and unipolarity decrease with increased contact pressure. With increased potential between the contacts the contact resistance remains unaltered. A. W.

913. *A Comparative Method of Testing Thermionic Valves for Passing no Reverse Current at High Voltages.* **N. W. McLachlan.** (Phys. Soc., Proc. 32. pp. 72–77, Feb., 1920. Radio Rev. 1. pp. 239–240, Feb., 1920. Abstract.)—A simple method of testing diode valves for passing no reverse current at voltages up to 20,000 is described. The anode of a standard valve, known to pass no reverse current, is connected to that of the valve under test, and the filaments are joined to the terminals of a high-tension alternating voltage supply A low-reading electrostatic voltmeter, with parallel condenser, is arranged to indicate if the valve under examination passes reverse current

A description of a method of using a diode valve *to measure the decrement of a highly damped oscillation* is given. This consists in arranging the valve connections of the circuit so that the first positive peak is obtained. The valve connections are then reversed, and the first negative peak is found. This method is applied to the measurement of the highly damped oscillations which occur after the primary current is broken in a magneto.

Erratum. (*Ibid.*, p. 316, March, 1920.) AUTHOR.

914. *Triode Valve Parameters.* **W. H. Eccles.** (Phys. Soc., Proc. 32. pp. 92–102; Disc., 102–104, Feb., 1920.)—At any given filament voltage or current the principal parameters of a triode are:—

1. The coordinates of the mid-point of the straight part of the lumped characteristic.
2. The voltage factor g.
3. The differential coefficient di_a/de_a or h_a.
4. The differential coefficient di_a/de_g or h_g.

Methods of determining these quantities are described. AUTHOR.

915. *Method of Measuring the Amplification of a Radio-frequency Amplifier.* **F. W. Jordan.** (Phys. Soc., Proc. 32. pp. 105–115; Disc., 115, Feb., 1920.)—The audio-frequency oscillations were generated by means of a tuning-fork, which was maintained in vibration by a triode valve. The a.c. voltage from the plate circuit of this valve was applied through a transformer to the plate circuit of a feeble radio-frequency oscillator. The radio-frequency oscillations were in this way separated into alternate semi-period trains of waves. The input energy to the amplifier was controlled by a sliding coil inductance. The radiating coil of this was loosely coupled through an auxiliary coil with the oscillating coil of the radio-frequency generator and the receiving coil was connected to the tuned receiving circuit of the amplifier. The receiving coil of this inductance was adjusted so that the intensity of the rectified oscillations, as received through the amplifier by the telephone, was the same as that of a standard source of sound of the fork frequency. The latter standard was furnished by applying a small a.c. voltage from the fork alternator circuit to the receiving telephone. The voltage amplification under these conditions is the ratio of the mutual inductances of the sliding coils (1) without the amplifier and (2) with the amplifier. A method of calibrating the mutual inductance and also methods of eliminating strong radiation are detailed. AUTHOR.

916. *Measurement of the Amplification given by Triode Amplifiers at Audible and at Radio Frequencies.* **F. E. Smith and H. C. Napier.** (Phys. Soc., Proc. 32. pp. 116–131; Disc., 131–132, Feb., 1920.)—The measurement of amplification at audible frequencies which is described is a mutual inductance method, the alternating voltage applied between the filament and grid of the first valve being varied by quickly changing the connections to an air-core transformer having two secondaries at right angles, which secondaries are capable of rotation so as to give any desired ratio of the mutual inductances between the primary and the respective secondaries. The source of alternating voltage is a triode circuit having such capacity and inductance in the oscillatory portion as to give currents of a sonic frequency. The standard intensity of note is such as to enable signals to be read with comfort, and is obtained by adjustment of the source of alternating current. The first note is obtained when the telephone is in the anode circuit of an auxiliary valve, and the second when the telephone is transferred to the anode circuit of the last valve of the amplifying set, changes also being made in the applied alternating voltage, and in the connections between the valve circuits. All of these changes are brought about by a six-brush switch in a fraction of a second, so that readings are quickly obtained.

The method is compared with a modification of the shunted telephone method, and very good agreement is obtained when the amplifying values are comparatively low. For values of a high order, such as 200, it is shown that the two methods are not likely to give the same results, the method described in the paper being the better one.

In the measurement of amplification of a radio-frequency amplifier an undamped train of oscillations is broken up into groups of sonic frequency by shunting intermittently the condenser in the oscillatory circuit by an inductance of low resistance. A sonic train of oscillations is thus produced. The receiving circuit is very similar to that used for audible frequency amplification, but the measurement of the amplifying power is made by quickly varying the current at the source, and not by a change of mutual inductance between the two circuits.

AUTHORS.

917. *Influence of Ultra-Violet Rays on the Conductivity of Solutions.* **M. Volmer.** (Zeits. Wiss. Photochem. 16. pp. 186–189, 1917.)—The conductivity of solutions of anthracene in hexane is largely increased when ultra-violet rays act upon the solution. In some cases the ratio of the conductivity when radiated was about 1000 to 2000 times as great as when the solution was in the dark. The rays producing the effect are those of wave-length $< \lambda = 225\,\mu\mu$. A similar effect is observable with solutions of methylanthracene, phenanthrene, chrysene, stilbene, α- and β-naphthol, diphenylamine, α-naphthylamine, quinizarine, and naphthazarine. L. H. W.

918. *New Cadmium-Vapour Arc-Lamp.* **F. Bates.** (Phil. Mag. 39. pp. 353–358, March, 1920. Bureau of Standards, Bull. 16. pp. 45–50, [Sci. Papers, No. 371], 1920. Chem. News, 120. pp. 278–281, June 11, 1920.)—The cadmium lamp described by Lowry and Abram [Abs. 1827 (1914)] is unsatisfactory in that it must be permanently connected to an air-pump, and the electrodes must be immersed in water. Also, if the cadmium is sufficiently pure, the adhesion between the cadmium and the quartz results in the destruction of the lamp upon the solidification of the cadmium. In Sand's improved form [Abs. 607 (1916)] the introduction of a small amount of zirconia lessens the tendency to breakage slightly, but extensive experiments have shown that it is impracticable, provided a pure cadmium spectrum is desired. Experiments with a Cd-Hg alloy (the constituents being varied over a wide range) showed that the introduction of the mercury is very effective in preventing the cracking of the lamp, but it was impossible to obtain a brilliant cadmium spectrum under any circumstances on account of the fact that the vapour-pressure of mercury is much higher than that of cadmium. Very much better results were obtained by substituting gallium for the mercury. The purified gallium used has a freezing-point of 30·8° C., and it was found that the addition of a few drops to 10 or 15 $cm.^3$ of cadmium completely changed the texture of the latter, rendering it relatively soft, and greatly reducing its tensile strength. Even when distilling the cadmium from the alloy at a pressure of 0·001 mm. of mercury, the minute quantity of gallium carried over was sufficient to prevent any adhesion between the cadmium and the walls of the lamp. The lamp finally evolved is of an inverted U-shape, the electrodes of tungsten wire entering through quartz capillaries, which are closed with lead seals similar to the type described by Sand. The lamp operates on an ordinary 110-volt lighting circuit, the best results being obtained with a current of about 7 amps. and a drop across the lamp terminals of about 25 volts. Under this condition a brilliant cadmium spectrum is obtained, and since the spectrum of gallium contains but five lines in the visible spectrum ($\lambda\lambda$ 3020·61, 4033·18, 4172·22, 6396·99, and 6413·92), and none of these lie between λ 4200 and λ 6400, the cadmium spectrum is almost pure. Lamps constructed with the cadmium-gallium filling have a practically indefinite life. One has been in use for over a year and shows no signs of deterioration. A. W.

919. *Thermoelectric Cell of Constant Voltage.* **C. R. Darling.** (Phys. Soc., Proc. 32. p. 134, Feb., 1920.)—This cell depends upon the constancy of the e.m.f. developed by molten bismuth and aluminium over a wide range of temperature. An iron vessel is provided with a side branch of silica tubing, about 10 in. long, both being filled with bismuth. An Al wire covered with graphite passes through the lid of the vessel into the molten Bi, and forms the hot junction, the cold junction being similarly formed at the remote end of the silica tube, and kept in oil in a vacuum flask. On placing a burner beneath the vessel the e.m.f. rises to 15 micro-volts at the melting-point of Bi (267° C.), the cold junction being at 15°, at which voltage the cell remains constant over a further 300°. It has been found useful as a closely approximate standard in measuring thermal e.m.f.'s, and as a "set-up" against another e.m.f. when using a pyrometer indicator for measuring special ranges. The internal resistance of the instrument described is approximately 0·5 ohm.

AUTHOR.

920. *Apparatus for the Production of High Static Voltages.* **J. J. Dowling.** (Roy. Dublin Soc., Proc. 15. pp. 673–676, Jan., 1920.)—A simple apparatus on the principle of the "condensing electroscope" of Volta operated in a continuous manner as in Einstein's "potential multiplier." The condenser consists of two plane circular plates, and an oscillatory motion is provided for by means of an eccentric, thus periodically altering the distance apart of the plates. At 5 oscillations per sec., due to the eccentric, the equivalent current, when multiplying 800 to 4000 volts, is about ½ microamp. Such a voltage can be maintained constant to within 1 or 2% for several hours. L. H. W.

921. *Vibration Galvanometer.* **P. G. Agnew.** (Bureau of Standards, Bull. 16. pp. 37–44, [Sci. Papers, No. 370], 1920. Am.I.E.E., J. 39. pp. 158–161, Feb., 1920.)—Describes a new form of vibration galvanometer, which consists of a fine steel wire mounted on one pole of a permanent magnet, and so arranged that the free end may vibrate between the poles of an electromagnet through which the current to be detected passes. The sensitivity, though less than that of instruments of the moving-coil type, is higher than that of other moving-iron instruments, while it possesses the qualities of sturdiness, quick responsiveness, and freedom from the effects of external vibration. J. W. T. W.

922. *Neon Lamps for Stroboscopic Work.* **F. W. Aston.** (Cambridge Phil. Soc., Proc. 19. pp. 300–306, Feb., 1920.)—In the neon discharge nearly all the light is in the positive column, and its brightness increases with the current density. The lamps were accordingly designed to give a positive column as long and narrow as possible consistent with the potential available, two relatively large spaces containing the electrodes being connected by a very long capillary tube doubled backwards and forwards like the filament of an ordinary incandescent lamp. In the lamps constructed the capillary is about 60 cm. long by 1 mm. diam., and is coiled up inside the space containing the anode. This type of construction, besides being convenient and strong, has the additional advantage of being strongly unsymmetrical to the discharge, allowing it to pass much more easily in one direction than the other. The electrodes are of aluminium, and may be of any form so long as they are not too small. The method of filling is described. The best results have been obtained from a batch of lamps filled at about 10 mm. pressure, some with pure neon, some with a mixture of neon and about 10% helium. One of the latter had a working life of well over 3000 working hours, helium disappearing from its spectrum after the first few hundred hours. A. W.

ALTERNATING CURRENTS AND MAGNETISM.

923. *Remanent Magnetism, Spontaneous Magnetism, and Temperature.* **A. Perrier** and **G. Balachowsky.** (Archives des Sciences, 2. pp. 5–29, Jan.–Feb., 1920.)—Experiments were made on the variation with temperature of the remanent magnetism of iron and nickel in zero magnetic field. The specimens were thin wires 15 cm. long; these were placed in a suitable vertical magnetising coil within an electric resistance furnace; and the magnetometer indicator was an astatic system of two vertical needles. The demagnetising field due to the test piece, and the

vertical field of the earth were neutralised, an experimental device being adopted by means of which this could be conveniently and rapidly done. The furnace wire was wound lengthways on a hollow brass tube, to avoid magnetic action. The author's theory requires the condition of reversibility to hold, and this is found to be the case, as shown by the curves of remanent magnetism and temperature. The temperatures found for the disappearance of remanent magnetism were: Ni, 361·2°; Fe, 763°. The general theorem is stated that the remanent magnetism varies with temperature according to the same law as the spontaneous magnetism of the elements, whatever may be the initial value of the former. In support of this it is pointed out that the given curves are almost identical with the curves of saturation intensity given by Hegg and Renger. Properly speaking, there is only one function, $I_r = f(t)$, for each ferromagnetic, and these functions for different substances are related in the same way as $I_{max.} = f(t)$. G. E. A.

924. *K.S. Magnet Steel.* **K. Honda** and **S. Saitô.** (Phys. Math. Soc. Japan, Proc. 2. pp. 32–38, March, 1920.)—A description of a steel alloy discovered by Takagi and Honda. A favourable range of the constituents is: C, 0·4–0·8%; Co, 30–40%; W, 5–9%; Cr, 1·5–3%. Its best quenching temperature is 950° C., and the best quenching bath a heavy oil. The steel requires almost no heat-treatment in order to be used as a permanent magnet in electrical instruments. The values found for the coercive force varied from 215 to 257, or about three times greater than that of the best tungsten steel hitherto known. Its residual magnetism is also greater than that of tungsten steel. The Brinell hardness numbers for the alloy were 444 (annealed), and 652 (quenched); the corresponding Shore numbers were 38 and 55. The hysteresis loss was 909,000 ergs (best tungsten steel, 209,000). When artificially aged by heating in boiling water for 40 hours, there was a slight increase in residual magnetism, this having taken place in the first three hours' heating. Repeated shocks by fall caused the residual magnetism to decrease from 854 to 800, after 850 falls of 1 metre on to a concrete floor. The residual magnetism increases rapidly with the dimension ratio up to the ratio 20, after which it is unaffected by the ratio. The steel when quenched is mechanically very hard, and has a very fine microstructure. It is specially suited for short bar magnets. G. E. A.

925. *Torsional Magnetic Energy Absorption of an Iron Conductor.* **C. Barus.** (Nat. Acad. Sci., Proc. 6. pp. 59–61, Feb., 1920.)—The twist produced in a vertical thin tube of low-carbon steel when subjected to a circular magnetising field was measured by an interferometer method. The twist for a given field is established immediately. On reversing the magnetising current the fringes are displaced in the opposite direction and maintain their new position however often the current is made and broken. With a magnetising current less than 3 amps. no effect was observed. For large currents the twist increased proportionally with the current. Assuming that the resistance to magnetic set is the same as the elastic resistance for the same twist the energy absorbed per unit volume for a given magnetising current is calculated. Observations with an applied longitudinal magnetic field showed that the residual torsion effect due to the circular field could be gradually eliminated. L. L.

926. *Note on the Decay of Magnetism in Bar Magnets.* **W. Brown.** (Roy. Dublin Soc., Proc. 16. pp. 78–82, March, 1920.)—Some ten years ago the author recorded observations on the moments of steel magnets of various compositions [Abs. 226B (1910)]. These magnets were put away from all disturbing influences, and have remained in a vertical position for about ten years. Their moments have now been re-determined. In the paper the author tabulates (1) composition, (2) dimension ratios, (3) moment per gm. in December 1909, 6 months after magnetisation; (4) percentage loss in moment after 6 months, (5) moment in January 1920, (6) percentage loss after interval of about 10 years.

Fairly high C. (1·09%) and Mn (0·32%) content are advantageous for a permanent magnet, although the moment is not very high. More than 2·5% of Cr appears detrimental to the permanency. A steel containing about 7·5% W makes the most permanent magnet. Of seven magnets of chrome-steel it would appear that high Si content decreases the retentivity.

The percentage loss in moment per gm. when the magnets are allowed to fall four times from a height of 4 m. on a block of glass is also recorded. L. L.

927. *Absolute Retardation in the Kerr Phenomenon.* **Pauthenier.** (Comptes Rendus, 170. pp. 803–805, March 29, 1920.)—In a previous paper [Abs. 623 (1920)] the author has pointed out the necessity of short duration of charge for the condenser if the Joule electrostriction effect is to be eliminated. For nitrobenzene and times of charge varying from $4 \cdot 6 \times 10^{-7}$ sec. to $9 \cdot 2 \times 10^{-7}$ sec. he finds the retardation varies from $-2 \cdot 01$ to $-1 \cdot 99$. This agrees with the theoretical value, -2, within the limits of the observational errors. L. L.

928. *Magnetic Elements at U.S. Coast and Geodetic Observations during Solar Eclipse,* 1919, May 29. **D. L. Hazard.** (Terrest. Magn. 24. pp. 161–167, Dec., 1919.)—At the five observatories, Vieques, Cheltenham, Tucson, Sitka, and Honolulu, values of D, H, and V are tabulated for every 5 minutes from 10h. to 16h. 30m. on the day of the eclipse, with diurnal variations for undisturbed days in separate tables. The value at any time is not the instantaneous value, but the mean value for the 5-minute interval centred at the given time. W. W. B.

929. *Magnetic and Electric Observations made during the Solar Eclipse of June* 8, 1918. **L. A. Bauer, H. W. Fisk, and S. J. Mauchly.** (Terrest. Magn. 23. pp. 95–110, Sept.; 155–190, Dec., 1918; 24. pp. 1–28, March, and pp. 87–98, June, 1919.)—A lengthy account of the observational work planned, and of the results of the observations. There are in all 108 separate sectional paragraphs, and it is impossible to give an adequate summary in a brief abstract. L. H. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

930. *Separation of Chlorine into Normal Chlorine and Meta-Chlorine, and the Positive Electron.* **W. D. Harkins.** (Nature, 105. pp. 230–231, April 22, 1920.)—Aston's work [Abs. 265 (1920)] gives much evidence in favour of a theory of the structure and composition of the nuclei of complex atoms advanced by the author of the present paper. Experiments carried out on the fractional diffusion of hydrogen-chloride gas on a large scale seem to be resulting in a definite separation of the gas into a heavier and a lighter fraction. The separation, while extremely slow, seems from preliminary results on the heavier fraction to be of about the order to be expected from the Rayleigh diffusion theory, provided the atomic weights of the isotopes of chlorine are 35, and 37, as found by Aston. A third isotope of higher atomic weight may possibly exist. The latter part of the paper gives a brief statement of the author's theory of atomic structure, and in this it is assumed that the hydrogen nucleus, or positive electron, has a weight of 1·000 on the basis of oxygen 16·000, the fact that the atomic weight of ordinary hydrogen is 1·0077 being explained as due either to the existence of meta-hydrogen of atomic weight 3·00, or else to an electromagnetic packing (or possibly to both). **E. W. Aston.** (*Ibid.*, p. 231, April 22, 1920.)—In connection with the possibility of a third isotope of chlorine, a description is given in the full account of recent work on this element (now in the press), of a faint line at 39, which may be the third isotope. It is pointed out that Harkins' basal assumption that the positive electron has a weight 1·000 is definitely contradicted by experimental results obtained by Aston [see Abs. 721 (1920)]. A. W.

931. *Chemical Structure of the Atoms.* **F. Wenzel.** (J. prakt. Chem. [II]. 98. pp. 155–203, Dec. 5, 1918.)—I. *Typical Elements.*—Since the views of Le Bel and of Werner do not solve the affinity problem, the author suggests structural forms of atoms starting from two hypotheses: (1) The tervalent nitrogen atom contains two nuclei joined by a double linking, but there are really seven valencies, and (2) the mass 14·01 of the N atom is uniformly distributed over these 7 valencies, giving a valency mass of approximately 2 units. This is the usual valency mass; in lithium, glucinum, boron, there must also be masses 3, however. Helium would then consist of 2 nuclei with a single link; Li of two masses 2 and one mass 3, total 3 masses; Gl of three masses 2 and one of 3, total four; B of four masses 2 and one mass 3, total five. In carbon, nitrogen, oxygen, and fluorine the numbers of valency masses would be 6, 7, 8, 9. In the second period similar relations hold, starting from neon. These structures could account for the chemical and physical properties.

II. *Valency Masses and their Mode of Linking.*—There must also be a valency mass 1. From the valency forces linking the masses the maximal values of the masses can be deduced, and it can be shown that these views would be compatible with the existence of a metallic form of nitrogen (in the ammonium compounds), with the deviations of the atomic weights from integer values, and with the metallic properties of hydrogen and the deviation of its atomic weight from unit value.

III. *Stereoisomerism of Ammonium Compounds.*—The isomerism of ammonium compounds is exceedingly complicated, and not even explained by Bischoff's pyramidal formula; the optical activity of some of these compounds can only be understood on the assumption of a binuclear nitrogen atom.

IV. *The Metallic Carbon Atom.*—Baeyer regarded the basic character of one of the carbon valencies as a carbonium valency. In the ordinary metalloid carbon atom the valencies are directed tetrahedrally; in the metallic carbon atoms the metallic carbonium valency lies in a plane at right angles to the plane of the three metalloid valencies, and this agrees with the spacial disposition in the graphite as disclosed by X-ray studies of crystal structure. H. B.

932. *Ammonia Synthesis by the Electric Arc.* **E. Briner** and **A. Baerfuss.** (Helvr. Chim. Acta. 2. pp. 95–100, Feb., 1919.)—Experiments were made with mixtures of N and H in different proportions with electrodes of various metals and at ordinary and reduced pressures; there is no mention of high pressures. Electrodes of Pt give better yields per amp.-hour than iron and copper; in the case of Fe and Cu the low pressure (100 mm.) reduced the yield much, and the volume proportion 1 : 3 of the gases proved best. For these mixtures the pressure had no influence; when N is present in excess, the proportion 3H : 15N doubled the yield at 100 mm. It is suggested that the agents being the atoms, not the molecules, the required dissociation is produced by the high temperature of the arc and by the collisions between ions and molecules; the latter is favoured by low pressure, and an excess of nitrogen is profitable because the activation of nitrogen is more difficult than that of hydrogen. There are also remarks on the influence of electrode thickness and arc length. The max. yield obtained was 10 gm. of NH_3 per kw.-hour, the volume concentration of the ammonia ranging from 0·6 up to 1%. H. B.

933. *Baeyer Strain Theory and the Structure of the Diamond.* **E. Mohr.** (J. prakt. Chem. [II]. 98. pp. 315–353, Dec. 30, 1918.)—According to Baeyer (1885) a strain is set up in the molecule of a carbon compound when the valencies of the C atoms cannot act in the normal tetrahedral direction, but are, by the union to a ring, forced to act in another direction. The strain increases with the deflection; it amounts to 54° 44′ in the ethylene ring, and only to 44′ in the penta methylene ring. The most stable compound would be black coal, in which there are few deflections; we should now apply this to diamond rather than to black carbon. The author—presuming that, unless otherwise stated, the C atoms are only subject to these stresses—considers the stability of the cyclohexane ring, the isomerism of which is explained by Sachse's model (1890), according to which the strains are smallest when the centres of gravity of the ring carbon atoms lie in the same plane, and passes to complex cases by the normal or oblique superposition of several cyclohexane rings, free valencies existing only of the surfaces. These oblique carbon-atom systems would be identical with Bragg's diamond space-lattice. But for rings of more than six carbon atoms the strains are complicated by other factors, and do not, so far, admit of calculations. H. B.

934. *Electrical Synthesis of Colloids.* **T. Svedberg.** (Kolloid Zeits. 24. pp. 1–7, Jan., 1919.)—The author first refers to the work of the late

I. Nordlund (Dissertation, Upsala, 1918) on mercury hydrosols and on the advantages of preparing colloidal mercury by mechanical or electrical means, by injecting it into water (or aqueous solutions), by passing superheated steam through the mercury, and by the aid of alternating or direct currents. These electric methods, especially alternating currents, give the greatest proportion of very highly disperse, ultramicroscopic particles, but the effect is essentially thermal, and the author describes his three methods of preparing colloids as electrothermal colloid syntheses: (1) A thin foil of gold or silver is attached to a glass plate (by gum arabic), immersed in ethyl alcohol, and brought in contact with two iron-wire electrodes carrying 10 amps. at 440 volts; the volatilised metal condenses in the alcohol as an alco-sol. (2) As in (1), but the metal (also Zn, Sn, etc.) is used in the form of a narrow strip, ending in stouter copper terminals, to which the iron electrodes are applied. (3) The metal is itself a thin wire connecting the iron electrodes. The melting metal always breaks up into globules between which arcs are formed, vaporising the metal. In the case of lead particularly, there seems to be some sputtering of fused metal in addition to gasification; but the line spectrum observed proves that there is a considerable amount of gasification. The methods are not new, of course, since Van Marum volatilised metals by the Leyden jar discharge in 1787. [See also Abs. 168 (1920).]
H. B.

935. *Oxidation of Carbon Monoxide on Contact with Copper.* **K. A. Hofmann.** (Deutsch. Chem. Ges. Ber. 51. pp. 1334–1346, 1918.)—In his volumetric oxidation of hydrogen by means of the sodium chlorate pipette (*ibid.*, 49. pp. 1650–1662, and pp. 1663–1669, 1916), the author observed that the presence of CO, which was itself oxidised, prevented the hydrogen absorption. Looking for reagents which will oxidise CO at ordinary temperature, he finds that copper oxide and, better still, metallic copper will favour this oxidation in the presence of aqueous alkali, especially when iridium or other platinum metals are present.

Activation of Carbon Monoxide by Metallic Copper, the Generator Gas-Cell and Electromotive Activation of Alkali Formates. (*Ibid.*, 51. pp. 1526–1537, 1918.)—The research had led to the construction of a patented generator gas-cell—technical description of which is officially deferred—of the type O | Cu | alkali | Cu | CO. The e.m.f. is said to be 1·32 volts at 20°, which would agree with the calculation of Nernst and Wartenberg, based upon the dissociation of CO, viz. 1·343 volts at 17°. Scientific problems are alone discussed; the activation of the CO is ascribed to the formation in the presence of copper, not of formate, but of a labile *iso*formate OH . C . OK.
H. B.

936. *Apparent High Pressure due to Adsorption, the Heat of Adsorption, and the Density of Gas-Mask Charcoal.* **W. D. Harkins** and **D. T. Ewing.** (Nat. Acad. Sci., Proc. 6. pp. 49–56, Feb., 1920.)—In connection with the determination of the pore volume of charcoal the authors have found that the volume of water or of an organic liquid taken up by a definite weight of any charcoal which is very efficient as an adsorber of gases, increases as the compressibility of the liquid increases, or as either the viscosity or surface tension decreases. The charcoal was "out-gassed" at 600°, the process being continued until the pressure in the system fell to one ten-thousandth of a mm., and remained of that order for about six hours. The tube containing the charcoal was sealed

off while still at 600°, and opened under the hot liquid which had just been boiled to drive off dissolved gases; the determinations were then made at 20°. The apparent density of the charcoal in mercury, which does not enter the pores, was 0·865, whilst in water it was 1·843. With various organic liquids it varied from 1·960 in propyl alcohol to 2·120 in ether and 2·129 in pentane. The differences in the volume of liquid absorbed may be due either to the compressibility or viscosity of the liquid, but on the whole they are in better agreement with the idea that it is the compressibility which is effective. The difference between the volume of ether and water absorbed is about 10%, and to produce this difference of volume by pressure exerted on the whole volume of liquid would require, according to Bridgman's data, between 4000 and 12,000 atmos. The average pressure in the primary film (average thickness 4×10^{-8} cm.) due to the attraction of the carbon would probably need to be more than 20,000 atmos. higher than the normal internal pressure of the liquid. This theory would give low values for the density of active carbon, namely, a density of about 1·6. Those charcoals which do not adsorb more ether than they do water are extremely inefficient in adsorbing gases. A highly outgassed coconut-shell charcoal gave a heat of adsorption equal to 10·5 cals. per gm. of charcoal when immersed in enough water completely to fill its pores and voids. The same charcoal dried for ten days at 120°–150°, and then cooled over phosphoric oxide, had a smaller heat of adsorption, 7·0 cals., whilst it gave only 3·5 cals. when it held a thin film of water equal to 0·04 gm. per gm. of charcoal. Thus the first tenth of the water which penetrates the pores gives rise to nearly all the evolution of heat. Bone charcoal and fuller's earth have a much higher heat of adsorption than even the best grades of coconut-shell charcoal. From the results of other experimental work which is being carried out it appears that most of the heat which appears is due to the fact that the interfacial free energy, carbon-liquid, is very much smaller than the free surface energy of the solid carbon. The heat of adsorption of the liquid is equal to the energy of adhesion between the liquid and the carbon, minus the total surface energy of the liquid. In the case of water this total surface energy is moderately large, so that the heat of spreading of the liquid is considerably less than the adhesional energy. T. S. P.

937. *Charcoal Activation.* **H. H. Sheldon.** (Phys. Rev. 15. pp. 135–136, Feb., 1920. Abstract of paper read before the Am. Phys. Soc., Nov., 1919.)—Recently there have been published papers dealing with charcoal activation, which propose a hydrocarbon hypothesis, but there is a lack of published data, either in support of or in contradiction to this theory. In the case of hydrogen, for out-gassing temperatures below 600° the activity of the charcoal is not affected, which shows that activation below this temperature must be entirely due to oxidation. At 700° the activity is increased, showing that, according to the hydrocarbon theory, the boiling-points of some of the inactive hydrocarbons have been reached. When no further activation could be produced at this temperature, 800° was, however, effective. At 900° de-activation was found to take place slowly, which indicated that the basic structure, or active carbon, was being modified. The de-activation was very decided at 1000°. So far the evidence for the hydrocarbon theory seems to be excellent, but a most significant fact is that charcoals de-activated so far as the adsorption of nitrogen is concerned remain nearly as good for hydrogen as before treatment, regardless of what gases may have been in the charcoal during, or previous to, the high-temperature treatment. A sample of charcoal which, at liquid-air temperature, will adsorb 2000 cm.^{3} (normal) of nitrogen, may be de-activated so as to adsorb 400 cm.^{3}, and still remain unchanged to within 50 cm.^{3} so far as hydrogen is concerned. This suggests that hydrogen adsorption must be, to some extent, a different thing from nitrogen adsorption, and it is suggested that, apart from surface condensation, the hydrogen may, at the same time, act chemically to form an easily dissociated hydrocarbon. Since this secondary action in the case of nitrogen would not be expected, this would class hydrogen adsorption as quite different from nitrogen adsorption. T. S. P.

938. *The Influence of Cold-rolling upon the Mechanical Properties of Oxygen-free Copper.* **F. Johnson.** (Inst. of Metals, J. 21. pp. 335–346, Disc. and Corres., 347–376, 1919. Engineering, 107. pp. 440 and 454–455, April 4, 1919.)—Contains the results obtained in an investigation undertaken to ascertain whether the presence of cuprous oxide was in any way responsible for the phenomenon previously noted by W. E. Alkins, that by progressively cold-drawing copper wire, a stage is reached when the area of the wire has undergone a reduction of about 50%, where, over a limited range, further drawing causes no corresponding alteration in properties; also to ascertain whether the same kind of change would occur if the metal were cold-rolled instead of being cold-drawn.

Copper practically free from oxide was obtained by melting electrolytic copper under a cover of charcoal, and the metal obtained was forged to ½-in. thickness. This copper was then cold-rolled by means of 16 passes, the thickness being progressively reduced from 31·8 to 99·22%, and samples removed and tested after each pass. When the results of the tests are plotted against percentage reductions in thickness, the tensile strength curve is found to consist of two rectilinear portions joined by a curved portion from about 35 to 65% reduction in thickness, during which range there is a marked check in the rate at which the tensile strength increases. Brinell-hardness figures do not indicate a marked change in hardness values to correspond with the change indicated by the tensile tests; scleroscope tests, however, show a marked change at about 50% reduction, and a change of direction at 80%.

The results show that the change of state shown by Alkins occurs with pure copper free from oxygen, and in sheet rolling as well as wire-drawing. The results of further tests on an annealed series are also given, which indicate a sharp change in direction at about 80% reduction, the max. stress rising and the elongation falling. C. O. B.

939. *Properties of some Copper Alloys.* **W. Rosenhain** and **D. Hanson.** (Inst. of Metals, J. 21. pp. 253–264; Disc. and Corres., 265–274, 1919. Engineering, 107. pp. 418–420, March 28, 1919.)—Describes the method of preparation and mechanical properties of certain copper alloys. The first series contained from 0 to 7% Mn, and 0 to 7% Al. The second series contained 2, 3, or 4% of Mn, with 10% Zn, or 5 or 10% Ni, with 5, 7, or 10% Zn. Some of the difficulties met with in the manufacture of these alloys are given, and the methods used to overcome same. The melting, casting, pressure casting, and rolling

of the alloys receive attention. A description is given of the Tomlinson method of pressure casting. C. O. B.

940. *Hardening of Screw Gauges.* **W. J. Lineham** and **G. T. White.** (Engineering, 109. pp. 593–597, April 30, 1920.)—The correct temperatures for hardening steel are deduced from the arrest or recalescence points on the cooling curve for carbon-steel. The Horstman Brothers found the eutectoidal point (700° C.) to be suitable for quenching. The researches here published start at that point. The results are displayed in twenty-nine figures, most of them being sets of curves connecting the temperature of quenching, as abscissæ, with the extension in length of the gauge quenched. The results may be grouped under two headings: (*a*) Quenching at 690°–700° in water, and (*b*) quenching at 717° in machine oil. In both cases the increase in pitch produced by quenching is no more than 0·2 mil for a length of 0·7 in., which is within the tolerance of 0·3 mil allowed for these gauges. The complete process is as follows: A very mild steel (0·14% carbon) is used for the blanks. These are screwed on a corrected lathe with a true screw-form tool to a fine polish, leaving a screw perfect in form while yet in the soft state. Next comes the hardening process in a furnace filled with sodium cyanide, heated by coal-gas and air, and thus kept at from 750°–770°, the temperature being shown by a platinum-rhodium thermo-couple. The gauges are soaked in this bath for from 10 minutes to 1 hour, according to size, and till the requisite depth of case (say 5 mils) is produced. For greater depth of case a special furnace of barium carbonate and bone-black at 850° is used, but the final heating must be in the cyanide furnace. After the cyanide bath a Brayshaw salt-bath furnace is used to let the temperature even up. Quenching comes next. Then the gauges are measured for diameters and pitch to 0·1 mil. The whole volume of the gauge remains constant, but the ends of the screwed cylinder increase most in diameter. The ideal is so to arrange that the screw shall not require any lapping after hardening. Lapping, even to a small depth, produces some local relief of strain and causes irregular shape just as in the case of removing a small shaving from a surface of wood. The quenching in oil, after casing in cyanide, is found to cause less distortion than when water quenching is adopted. And in the former case it is found that when the screws are made accurate in pitch and are made two-thirds below high limit and one-third above low limit, lapping can be dispensed with, and yet the screws, after a polish, are ready for high screw-gauge purposes. P. E. S.

941. *Some Studies of Metals by Means of X-Rays.* **S. Nishikawa** and **G. Asahara.** (Phys. Rev. 15. pp. 38–45, Jan., 1920.)—*X-ray patterns of metals; (1) effect of rolling.*—By passing a narrow beam of heterogeneous rays through a thin sheet of metal, a pattern may be photographically recorded which depends on the crystalline structure of the metal. The authors have used this phenomenon to study the effect of rolling and subsequent annealing on various metals. (*a*) In the case of *aluminum, cadmium, copper, zinc,* and *brass,* rolling produced ill-defined patterns, all with a symmetry related to the direction of rolling but each characteristic of a particular metal. (*b*) *Silver* and *tin* gave similar ill-defined patterns immediately after rolling, but these gradually changed during the following two or three weeks to the distinct spot patterns characteristic of annealed samples. For these metals, then, the growth which accompanies annealing takes place at room temperatures. Even at 5° the recovery from rolling goes on, though more slowly. (c) *Lead* and *thallium* gave irregularly distributed spots which showed no symmetry related to the direction of rolling. For these metals, then, either the crystal structure is not distorted by the rolling or the recovery is quite rapid. In the case of thallium, however, the pattern was not the same as after the sheet had been annealed. (2) *The effect of annealing after rolling* was studied with a special furnace which enabled the patterns to be obtained for a sheet of metal kept at any desired temperature up to 800°. The various metals differ greatly in their response to annealing. Thirty minutes at 80° is sufficient to obliterate the effects of rolling in the case of *silver* and *tin*, whereas 2 hours at 800° is not sufficient for *copper*. The effects of annealing *cadmium* at 100°, 150°, 200°, and 250° are shown in photographs. This method should be very valuable for studying the effect on metals of various mechanical and heat treatments.

Transformation point of thallium and tin as determined by X-ray patterns.—When the pattern produced by a thin sheet of annealed *thallium* was photographed for a series of ascending temperatures, it was found that as the transformation point was passed, the pattern suddenly changed to one corresponding to a single crystal. On cooling the sheet, the change was reversed. Taking account of the lag, the temperature of transformation was found to be about 227°, in good agreement with determinations by other methods. *Tin* was also investigated in this way, especially in the neighbourhood of 160°, but no change of pattern was observed. AUTHORS.

942. *Vapour Pressures and Free Energy of the Hydrogen Halides in Aqueous Solution: Free Energy of Formation of Hydrogen Chloride.* **S. J. Bates** and **H. D. Kirschman.** (Am. Chem. Soc., J. 41. pp. 1991–2001, Dec., 1919.)—The method used by the authors to measure the vapour pressures of hydrogen halides in aqueous solution consisted in the determination of the hydrogen halide contained in a given quantity of air in equilibrium with its aqueous solution and in the comparison of this with the amount of water vapour which the same air contains when in equilibrium with pure water at the same temperature. By this means partial pressures as low as 0·001 mm. may be measured accurately to a few per cent. The vapour pressures of hydrogen chloride, bromide, and iodide above their aqueous solutions between the concentrations 3·2 and 10·0 mol., 5·8 and 11·0 mol., and 6·0 and 9·7 mol. respectively, have been measured at 25° and that of hydrogen chloride between 5·5 and 9·2 mol. at 30°. The results obtained for hydrogen chloride solutions between 3·2 and 7·15 mol. are in good agreement with the e.m.f. data for hydrochloric acid concentration cells. The free energy of formation of hydrogen chloride at 25° is calculated to be —22,700 cals. The free energies of the halide acids in aqueous solutions of various concentrations at 25° are also given. T. H. P.

943. *Production of Carbon-Monoxide by the Combustion of Gases.* **A. Kling** and **D. Florentin.** (Comptes Rendus, 169. pp. 1404–1406, Dec. 29, 1919.)—Various industrial gases (coal, producer-, water-gas containing up to 60 % of CO) and also synthetic mixtures of methane and hydrogen with or without ethylene, are burnt in various burners (Bunsen,

fish-tail, Welsbach, gas stoves) within a room of 4 m.^{3} capacity, kept fairly cool by means of a cold-air coil, the flames burning either free or under a recipient chilled by cold water. The CO percentage is determined by the carboxy-hæmoglobin test of Ogier and Kohn-Abrest. Up to 150 litres of gas were burnt in each case within about an hour. It is found that the initial CO percentage has hardly any influence on the CO finally present in the combustion products, and that the CO percentage is much increased (from 0·18 to 1·3 in the case of the Bunsen) by chilling the flame; the Welsbach burners gave much more CO (0·74 against 0·17 %) with their mantles on than without them. The contamination of the air by the leakage of water-gas from leaky taps was found to be less serious than the contamination by the products of combustion. H. B.

944. *Influence of Different Metals on the Decomposition of Sodium Amalgam by Water.* **E. Müller** and **A. Riedel.** (Zeits. Elektrochem. 26. pp. 104–109, March, 1920.)—It is known that the rate of decomposition of sodium amalgam by water is considerably accelerated when the amalgam is put into contact with iron, and some time ago it was shown by Helbig (Ger. Pat. 275,047) that other metals, for example, Mo, W, V, and their alloys with iron, have a much greater catalytic effect than iron itself. The authors have carried out further experiments, using the alloys of iron with Mo, V, W, Si, and C, as also the individual substances Si, Cr, Pt, Pd, Ir, Ni, Co, Mn, Ta, graphite, cast iron, and wrought iron. Experiments were made with these substances, in pieces the size of a pea, (1) floating on and in direct contact with the sodium amalgam under the water, (2) not in direct contact with the amalgam but connected with it by means of a Pt wire, (3) not in contact, either direct or indirect, with the amalgam. The substances which showed marked catalytic activity were Cr, Ta, and the alloys of Mo, V, and W with iron. The cause of this activity is found to be that these substances go into solution and are then deposited as metal on the surface of the amalgam, whereby their surface is very much increased. Evidence in support of this is given, among other experiments, by the fact that the addition of a solution of ammonium molybdate to water in contact with sodium amalgam causes a violent evolution of hydrogen; the surface of the amalgam becomes covered with a black powder. Solutions containing 10^{-7} mol. Mo per litre show a catalytic effect, although Mo does not respond to ordinary analytical tests at such a concentration. Cast iron, in contact with the amalgam, has a strong catalytic effect, whereas wrought iron has very little influence. This is because the latter becomes amalgamated much more readily than the former; the two kinds of iron approach each other in activity after tempering, which reduces the tendency to amalgamation. T. S. P.

945. *Effect of Pressure and of Dissolved Air and Water on the Melting-point of Benzene.* **T. W. Richards, E. K. Carver,** and **W. C. Schumb.** (Am. Chem. Soc., J. 41. pp. 2019–2028, Dec., 1919.)—Benzene saturated with air under atmospheric pressure melts at 5·493°, which is 0·003 deg. below the true triple point, namely 5·496°. This correction is made up of two almost equal and opposing corrections, namely, those due to the lowering of the freezing-point by dissolved air, and to the raising of the freezing-point by increased pressure. Benzene thus saturated with air has its freezing-point but little altered by change of pressure, and there is no evidence of any important degree of supersaturation occurring. In the absence of dissolved air the freezing-point alters 0·029 deg. per atmosphere alteration in pressure. Saturation with water lowers the freezing-point of benzene 0·095 deg. T. S. P.

946. *The Activity-Coefficient for Ions.* **N. Bjerrum.** (Nobelinst. Meddel. 5. [Arrhenius Festskrift] No. 16. pp. 1–21, 1919.)—The effect of the electric forces upon the ions may be indicated by coefficients expressing the relation between the real value of a property and the value the property should have, supposing there were no electric forces acting between the ions. These are the activity-coefficient f_a, the conductivity coefficient f_μ, and the osmotic coefficient f_o. As regards f_o and f_μ the author refers to S. R. Milner [Abs. 1753 (1913) and Phil. Mag. 35. p. 352, 1918)], according to whom f_μ would be equal to f_a, and with whose arguments the author cannot agree; and to Ghosh [Abs. 881 (1918)], who makes the unwarranted assumption that electricity is only conducted by those ions the kinetic energy of which is greater than the average potential of the interionic forces per ion; potential would then be the work which must be done to separate the ions. The right view as to the interionic forces is probably that of Hertz; this, however, remains to be worked out. The experimental determination of f_a is difficult, because (1) dissociation is not complete and the degree uncertain; (2) we do not know what the activity of the ion would be if interionic forces did not exist; (3) because the water content of the ion and (4) the association of the water are uncertain. Potential measurements by Nernst's formula give only the activity of the hydrate ion, but not of the ion itself, without water. Referring to Harned's cell measurements (Am. Chem. Soc., J. 37. p. 2460; 38. p. 1986) and to Ellis [Abs. 1091 (1916)], the author calculates in detail that the ions of HCl contain about $9H_2O$, those of KCl about $2H_2O$, whilst the hydrogen ion alone seems to bind $9H_2O$, and the chlorine ion $2H_2O$, making $11H_2O$ for HCl. The values H^+8H_2O, Cl^+2H_2O, K^+OH_2O, seem more likely. There is the difficulty of eliminating the diffusion potential for the elimination of which the author prefers Henderson's method (Zeits. Elektrochem. p. 58, 1911) to Harned's method. H. B.

947. *The Critical Temperature as a Function of the Surface Tension.* **M. Prudhomme.** (J. Chim. Phys. 16. pp. 405–410, Dec. 31, 1918.)—Surface tension γ and temperature t are connected by the equations $\gamma = a - bt$ and $\gamma^{2/3} = a' - b't$. The former is valid within about 115° of the critical temperature at which $\gamma = 0$ and hence both the equations equal 0. The two equations give, however, different values t_1 and t_2 for the critical temperature, for which the equations do not hold exactly. Yet there is the simple relation $t_c = (t_1 + t_2)/2 = (a/b + a'/b')/2$, which holds for all substances obeying the Eötvös-Ramsay law, including liquefied gases like O, N, CO_2, as is shown by tables. Of substances which do not obey the Eötvös-Ramsay rule, the organic acids also conform with fair closeness to this relation; for alcohols and phenols the simple relation $\gamma = a - bt$ may be accepted. H. B.

948. *Occurrence of Fogs in Chemical Reaction.* **V. Rothmund.** (Monatshefte der Chemie, 39. pp. 571–601, Nov. 28, 1918.)—Fog formation (ammonia compounds, fuming of acids, oxidation of phosphorus, etc.)

is frequent, but little understood. Reviewing the history of the problem with respect to ozone and antozone (Schönbein, 1839), the author shows that the fog consists mostly of water particles containing part of the reaction product in solutions. Fogs are produced when the reagents are volatile and the products formed soluble in water ; by the solution the vapour tension is decreased, whilst the curvature of the drop is increased, so that the radius of the particles remains fairly constant; the radius is mostly about 5×10^{-5} cm. In the case of acid and potassium iodide the electric conductivity estimates yield too large values for the radius ; this is due to the formation of hydrogen peroxide. Reference is made also to condensation nuclei, to radium emanation fogs, town and country fogs, etc., which, though more or less distinct, are all of the nature of ozone fogs. H. B.

949. *Ionisation and Activity of Largely Ionised Substances.* **A. A. Noyes** and **D. A. MacInnes.** (Am. Chem. Soc., J. 42. pp. 239–245, Feb., 1920. Nat. Acad. Sci., Proc. 6. pp. 18–24, Jan., 1920).—As a measure of the degree of ionisation of salts, acids and bases, it is usual to employ the ratio of the equivalent conductance of the substance at any given concentration to the limiting value of the equivalent conductance as the concentration approaches zero, the ionisation in the latter case being assumed to be complete. This is, however, justified only if the mobilities of the ions may be regarded as constant up to the concentration under consideration; that such is the case is, in view of possible electrical effects resulting from the large electric charges on the ions, by no means certain.

In any case the conductance ratio furnishes no reliable information as to the chemical activity of ions, that is, as to the quantity which, when substituted for the concentration of the substance in mass-action expressions, denotes its effect in determining the equilibruim. The most obvious method of determining the relative activities of a substance in solutions of different concentrations is to find the concentrations in a gaseous phase in equilibrium with the solutions, since in gases at low pressure the concentration and activity may usually be assumed to be proportional. Since largely ionised substances seldom have appreciable vapour pressures, this direct method is of very limited applicability, and recourse is had, therefore, to a simple thermodynamic relation between activity and e.m.f. [see Abs. 1091 (1916) and 811 (1918)]. The results obtained with potassium, lithium and hydrogen chlorides and potassium hydroxide show that with all these substances the activity coefficient decreases with increasing concentration far more rapidly than does the conductance-viscosity ratio, the differences amounting to 7–15% at 0·1 mol. and to 5–18% at 0·5 mol. For the last three compounds the activity coefficient, unlike the conductance-viscosity ratio, passes through a pronounced minimum at about 0·5 mol. and then increases rapidly at higher concentrations. According to Harned's data (Am. Chem. Soc., J. 38. p. 1989, 1916), potassium chloride has a minimum activity coefficient at a concentration of about 2N. Even at moderate concentrations the activity coefficient varies considerably with the nature of the compound, its value for 0·5-mol. solutions being 65% for KCl, 73% for LiCl, and 77% for HCl and KOH.

The following general conclusions are drawn :—The conductance ratio can no longer be regarded as even an approximate measure of the activity of the ions of largely ionised compounds in their mass-action and thermodynamic relations. This activity varies with the concentration differently in the case of different substances, and for the present it can be determined only empirically for each substance with the aid of measurements of the chemical equilibrium, e.m.f. or freezing-point. Moreover, the activity coefficient of the ionic constituents can be neither proportional to nor mainly determined by the fraction of the substance ionised. Since, further, there is no property which affords any direct evidence of the existence of non-ionised molecules in solutions of most of the largely ionised inorganic compounds up to moderate concentrations, it seems advisable at present to assume that such compounds are completely ionised and to attribute the diminution in the conductance ratio wholly to decrease in ionic mobility and the change in activity coefficient entirely to some unknown effect of a physical nature. T. H. P.

950. *Double Layers and Surface Tension at Polarisable Electrodes.* **K. F. Herzfeld.** (Phys. Zeits. 21. pp. 28–33, Jan. 15, and pp. 61–67, Feb. 1, 1920.)—The paper is mathematical and confines itself to mercury surfaces in contact with a solution containing in addition to Hg-ions, also ions of a bivalent metal (Ca or Mg) and the corresponding anions (sulphate). It is presumed that the mercury electrode behaves, up to a sharp boundary, like an ideal conductor; that the mercury ions are not subject to any but electric forces, and that the neutral molecules are not constrained by any forces. The concentration of the mercury ions will correspond to the solution pressure, and Nernst's equation can, by Boltzmann's principle, be extended to the interior of the double layer, where potential and concentration change from point to point. A distinction between the Nernst potential and the absorption potential cannot logically be maintained. Following D. L. Chapman (Theory of Electro-capillarity, Phil. Mag. 25. p. 475, 1913), the author discusses the structure of the double layer due to natural polarisation; in that case the equations of Lippmann-Helmholtz and of Gibbs-Warburg give the same result. When an external polarising force is applied, the anion and the indifferent kation will, under the diffusion gradient established, not take part in the electrolytic conduction, which is entirely due to the Hg-ions. The potential is the sum of two terms, the first given by Nernst's formula and the concentration of the Hg-ions in the solution, the second depending upon the ohmic gradient in the capillary. The surface tension is not the same as with natural polarisation for the same potential; neither the Lippmann-Helmholtz, nor the Gibbs-Warburg formula are strictly applicable. Reference is made to similar considerations of Laue. H. B.

951. *Experimental Analysis of a Galvanic Cell.* **W. M. Coleman.** (Phys. Soc., Proc. 32. pp. 57–58, Feb., 1920.)—When the pressure in a galvanic cell is suddenly varied, the current in the external circuit is altered, an increase in pressure increasing the current, and *vice versa.* When the pressure in the neighbourhood of the zinc electrode is suddenly increased, and that in the neighbourhood of the copper electrode is diminished at the same time, an increase in current takes place, and *vice versa.* AUTHOR.

952. *Experiments on Osmotic-Electric Electromotive Forces.* **A. P. Carman** and **E. C. Fritts, Jr.** (Phys. Rev. 15. pp. 142–143, Feb. 1920. Abstract of paper read before the Am. Phys. Soc., Nov., 1919.)—The

following experiments have been made on the e.m.f.'s produced when water is forced through capillary tubes, in order to test the theories of Helmholtz and of Perrin. The e.m.f.'s were measured with a Wolff potentiometer and a standard cell. Pyrex glass, which has a negative or zero solubility in water, was used for the tubes and also for the containing vessels. The "ordinary distilled water" was freshly distilled from rain water in a fine tin-lined steam-heated still. The "extra-distilled" water was re-distilled in a quartz flask heated on an electric furnace, and collected in a Pyrex flask. Capillary tubes of sulphur, rosin, and sealing-wax were specially made. All the capillary tubes were of the dimensions to obey Poiseuille's law. The results confirm the law as stated by Quincke and Helmholtz, that the osmotic e.m.f. is strictly proportional to the pressure, provided the tube is long enough; this holds for a considerable range of pressures (from 0 cm. to 42 cm. Hg). Between 10° and 80° the temperature effect of the e.m.f. in glass tubes is zero. By using "extra-distilled" water in Pyrex glass tubes an e.m.f. as high as 60 volts per atmo. can be obtained for pressures up to 3·65 cm. of mercury. In a Pyrex tube with "ordinary distilled" water an e.m.f. of 8·4 volts per atmo. is obtained. In a special Jena glass tube with ordinary distilled water an e.m.f. of 2·4 volts per atmo. is obtained up to pressures of 31 cm. of mercury. With capillary tubes of sulphur, rosin, and sealing-wax, using ordinary pure distilled water, the e.m.f.'s are smaller. The results are 1·17 volts per atmo. for sulphur, 1·33 volts per atmo. for rosin, and 1·37 volts per atmo. for sealing-wax, with pressures up to 40 cm. of mercury. It is not yet evident how these results can be explained on Perrin's theory. T. S. P.

953. *Phenomenon after Anodic Polarisation.* II. **A. Smits, G. L. C. La Bastide** and **T. de Crauw.** (K. Akad. Amsterdam. Proc. 22. 4. pp. 296–299, 1920.)—In the previous paper [see Abs. 787 (1920)] it has been shown that nickel, after anodic polarisation in a solution of nickel sulphate, behaves similarly to iron in a solution of iron chloride. It is now shown that Ni behaves similarly when a solution of nickel chloride is used as the electrolyte, but the resumption of normal potential takes place much more quickly than with the sulphate electrolyte, owing to the catalytic action of the chloride ions. When, however, a solution of nickel chloride is used which has been heated for some time in a hydrogen atmosphere with finely-divided Ni, prepared by reduction of nickelous oxide at low temperature, the particular phenomenon in question is no longer evident. Thus Ni can be made to behave similarly to iron (*loc. cit.*).

When iron is polarised as kathode in a solution of ferro-ferric salt, the phenomenon after polarisation is similar to that observed after anodic polarisation. Immediately after the polarising current is cut off the potential of the kathode becomes about 30 millivolts less negative than the initial potential of the iron before the current was applied; the potential then rapidly falls to the normal value. T. S. P.

954. *Electrolytic Preparation of Potassium Ferricyanide.* **O. W. Brown, C. O. Henke,** and **I. L. Miller.** (J. Phys. Chem. 24. pp. 230–237, March, 1920.)—In the electrolytic oxidation of potassium ferrocyanide to potassium ferricyanide high current efficiencies cannot be obtained without the use of a diaphragm. The apparatus used by the authors was consequently as follows: A beaker, 11 cm. in diameter by

21 cm. high, capacity 2000 cm.^{3}, contained a porous pot in which was placed a cylindrical iron wire-gauze kathode. The anode was a 20-mesh copper wire gauze, 8 × 8 cm. held in a horizontal position about 2 in. from the bottom of the beaker. Just above the anode was a rotating glass stirrer, by means of which the electrolyte was forced through the space below the anode. In some experiments the beaker was replaced by a rectangular glass battery jar. Using a saturated solution of potassium ferrocyanide as electrolyte, and a current density of 0·9 amp./dm.^{2}, potassium ferricyanide can be made to crystallise out in the space below, instead of on the anode, voltage losses being thereby avoided. Potassium hydroxide is found in both anolyte and katholyte after the electrolysis, and special experiments showed that it increased the efficiency slightly and also decreased the voltage. All the ferrocyanide decomposed is not converted into ferricyanide, the current efficiency being about 96·5 %. The current efficiency is usually greatest after the electrode has been in use for about four hours, and experiments with different anodes (copper, nickel, Pt, Acheson graphite, lead covered with lead dioxide) showed that Acheson graphite gave the best efficiency, namely 99·7 %. T. S. P.

[illegible]5. *Mec[illegible]n of the Kathodic Deposition of Metal.* **V. Kohlschütter** an[illegible]. **Vuilleumier.** (Zeits. Elektrochem. 24. pp. 300–321, Oct. 1, 1918.)—The form of the kathodic deposits varies very much even when we remember that this electrolytic deposition is finally a crystallisation process. In the investigation the authors make use of a kathode foil of Pt (or Cu), 6·5 cm. by 2·5 cm., 0·1 mm. thick (or less), w[illegible]is clamped between jaws; to the free lower edge is soldered a P[illegible]ip spirally twisted which supports a glass pointer 30 cm. long. The back of the foil is insulated. When nickel is deposited on the foil (from chloride or acetate), the lower edge bends towards the anode, indicating a contraction in the nickel; when the nickel is dissolved again, the foil bends back. The apparatus is called a contractometer. Two processes should be distinguished: the deposition of the film, and the contraction of the metal film. The equilibrium position of the bending depends upon the electrolyte and the H-concentration and also on the grain of the metal; the contraction is small in deposits of fine grain. When a contracted deposit is charged with hydrogen, it expands; when the hydrogen is not liberated, the contraction may occur in jumps. The metal particles are first deposited apparently in a highly-disperse form, and they sinter subsequently into a denser metal; the gas layer simultaneously formed serves as dispersion medium. The first disperse film has a higher solution pressure than the denser metal forming; that accounts for the rise of the deposition potential. H. B.

956. *Chemical Decomposition and Electrolytic Formation of Sodium Hyposulphate.* **K. Jellinek** and **E. Jellinek.** (Zeits. Phys. Chem. 93. pp. 325–367, March 25, 1919.)—A continuation of the researches mentioned in Abs. 1060, 1061 (1911) concerning the decomposition of the salt in aqueous solutions and in solutions of sodium hydrogen sulphite (bisulphite) at 0°, 10°, 20°, 30° and various concentrations. The chief reactions are: $2Na_2S_2O_4 = Na_2S_2O_5 + Na_2S_2O_3$ and $Na_2S_2O_5 + H_2O = 2Na\,HSO_3$. Under special conditions discussed the yield of hyposulphite in the electrolysis with electrodes of various metals of bisulphite may reach 7 or 8%. H. B.